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THE JOURNAL OF PROSTHETIC DENTISTRY

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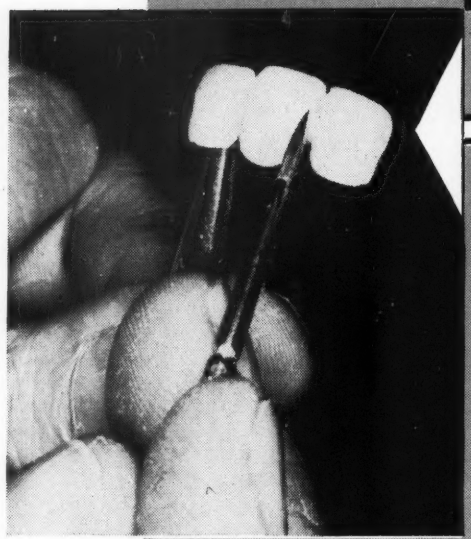

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THE JOURNAL OF
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THROUGH THE EYES OF THE EDITOR

Lindell L. Leathers reports that even though most dentists provide immediate denture service, many of them do so with reluctance. He describes his procedures, which should avoid the troubles that may tend to cause this attitude. His recommendations that a minimum trimming of the bone be utilized and that a labial flange be included are sound. He does not use surgical templates to guide the oral surgeon in the trimming, but others have found them to be most beneficial *when they are properly used.* If the bone trimming is not done accurately, the dentures will not be in their correct positions and the efforts exerted in impression building, occlusion, and esthetics will have been wasted. If the operation is done accurately, neither denture adhesives nor pressure-disclosing pastes should be necessary when the dentures are inserted. When a transparent surgical template is used properly, blood that may be under it does not interfere with its effectiveness as a guide to accurate surgery. He correctly emphasizes the importance of accuracy in the construction phases of this service, but if the surgical phase is not carried out accurately, the prosthodontist is blamed for (and must elminate) any failure of the dentures to fit the tissues or each other. This situation can be avoided.

Ira E. Klein discusses the advantages and disadvantages of immediate denture service and describes his technique which permits the use of the extracted natural teeth in the denture. His impressions are made in Thiokol rubber-base material with the same care and accuracy as for complete dentures made for edentulous patients. The procedure is unique in that the denture is completed in two stages. The first restores the teeth and occlusion in the edentulous areas. The second stage is completed immediately following the removal of the remaining anterior teeth. The crowns of the extracted teeth may be used by attaching them to the "first part" of the denture with self-curing acrylic resin, after the crowns of the teeth have been properly prepared. This is an ingenious technique and should produce extremely accurate immediate dentures.

Ronald V. Lam reports his studies of the changes in form of the residual ridges under immediate dentures. He compared the effect of "socketing" of the teeth with the effect of *not* socketing other parts of the same dentures. Periodic examinations and measurements revealed greater changes when teeth are "socketed." He recommends the use of a labial flange on immediate dentures to promote the preservation of the ridges.

John W. Geller describes the techniques used by the Indianapolis Dental Research Group for making complete dentures. The procedures have been selected after a study of many denture techniques. The emphasis, however, is not on the specific technique of construction, but, logically, it is on the principles and objectives involved in each step. The method can be varied, but if it is, the variation should not violate the fundamental principles.

Bernard A. Sussman discusses the effect of natural lower teeth, the incisal and condylar

guidances, and incorrect occlusion on complete upper dentures. He points out the causes for difficulties arising from these sources and suggests means of avoiding these difficulties.

George A. Hughes points out the fact that most current concepts involved in denture service are the result of clinical observation, rather than controlled research. Therefore, most of them represent "opinions" rather than "solid facts." He suggests that even though much progress has been made, many problems remain to be solved. Basic research is needed, and a number of areas with opportunity for it are listed.

Joseph S. Landa continues his discussion of the etiology and treatment of difficulties encountered by denture wearers. He discusses the various causes of lesions of the oral mucosa around and under dentures. A differential diagnosis is necessary and the treatment must be varied in relation to the cause. Too often, the only treatment used is an arbitrary reshaping of the denture at the location of the sore spot. In many instances, an entirely different treatment should be administered.

George S. Sharp discusses the causes of low tolerance to dentures in the mouths of some patients. He suggests that general, as well as local, conditions may require treatment. He observes that nutritional deficiencies cause the low tolerance to irritation of the oral mucous membrane and suggests dietary control and supplements as the treatment. Obviously, the mechanical irritation must be minimized also, if the treatment is to be successful.

The members of the Complete Denture Section of the Detroit Dental Clinic Club discuss diet and nutrition for denture patients in language that can be understood by the patients. This article was published originally in pamphlet form for distribution to denture patients. It should be helpful for explaining the facts of nutrition to denture patients.

Mortimer C. Davis describes the techniques he uses for making complete dentures and discusses the theories related to them. He recommends the use of "nonpressure" impressions and metal bases. Properly made metal bases have been found to be more accurate than those made from acrylic resins, but economic conditions may prevent some patients from having them. However, there can be little doubt about the superiority of dentures with metal bases. He points out three areas of agreement about impressions, but considerable controversy about them still exists. The extent of his denture borders is not as great as that used by many others. It would seem that so long as bone is the real support for dentures, the more area that is covered by the denture (within the limits of health and function of the surrounding tissues), the better the support. He raises the question of displaceability of tissue and doubts that it can be displaced. It might be helpful in this regard to observe what happens to dentures under varying closing pressures when the soft tissues are excessively thick. He follows the theories of Transographics and points out the four main concepts involved. While some of these concepts are controversial, they are discussed in a simple and concise manner. Probably, much of the controversy regarding them results from differences of interpretation and from the assigning of varying degrees of importance to the many factors involved. He places no importance upon occlusal balance or on the condyle path in denture construction.

There are many who would disagree with his downgrading of the importance of these factors involved in occlusion. Undoubtedly, some patients are not disturbed by the effect of ignoring occlusal balance or variations required by consideration of condylar guidances, but many others would be disturbed. The difference seems to be the result of the differences in the adaptability of patients and of the type of occlusion which was present in the natural teeth. The techniques described are well thought out and correlated with each other to satisfy a concept. This is important because *any* technique must be based upon a concept so the dentist knows exactly what he *expects* to happen and the way the various steps are related to the other steps. However, to consider any *one* concept or any *one* technique as the "solution to complete denture problems" for all patients is open to question.

Charles A. Brekke compares various concepts of the movements and positions of mandibular condyles during function. He disagrees with those who say that the condyles can be forced too far posteriorly. His reason is that the temporomandibular ligament prevents this situation. It is quite probably true that under *normal* conditions, the temporomandibular ligament does perform this function adequately. It is conceivable, however, that certain types

of malocclusion could force the condyles into a more posterior and superior position than would be desirable. For example, if six lower and six upper natural teeth were remaining, and if all posterior teeth were missing, the incline plane contact of the incisal edges of the lower teeth against the lingual surfaces of the upper incisors would put a posterior thrust against the mandible when closing force is applied. This posterior thrust *could* be sufficient to exceed the ability of the temporomandibular ligament to resist it. Thus, the condyle could be forced into a more retruded position than it would be in if the malocclusion did not exist. More than anatomy and mechanics is involved. The physiology of the structures involved is probably *the* determining factor. Even though the anatomy and the mechanics indicate that certain relationships could be expected, it does not necessarily follow that they will exist under *all* conditions.

When physiology is added to the anatomic and mechanical factors, the neuromuscular mechanism must be considered. When the neuromuscular mechanism is assigned its share of responsibility for condylar position, it is doubtful if "all power chewing" is done "against the temporomandibular ligament with the condyle anchored in hinge position." Likewise, this does not mean that *some* chewing cannot be done in the hinge position. The occlusion should be designed to accommodate *both* situations. This controversial problem is worthy of further study in order to determine the relative importance of *all* of the factors involved.

Avelino A. Macasaet discusses the diagnosis and treatment of asymmetry of the face when it is caused by malocclusion. The procedures he suggests seem to be sound. A thorough diagnosis is essential, because some asymmetry is "normal" and results from unequal growth on the two sides. Only the asymmetry resulting from malocclusion should be treated by modifying the occlusion.

Ennio L. Uccellani reports his studies of the effectiveness of a muscle relaxant as an aid in obtaining centric relation records. He concludes that it was ineffective for this purpose.

Finn Tengs Christensen discusses the effect of variations in Balkwill's angle on the cusp angulation of posterior cusped teeth or on the inclination of the occlusal plane when cuspless teeth are used. He suggests a simple formula to represent this relationship.

W. Alan Lawson discusses various methods that have been used for measuring masticatory force and points out their deficiencies or inaccuracies. On the basis of his tests and observations, he suggests another means for measuring these forces.

Oliver C. Applegate discusses the problem of evaluating the quality of support for partial dentures and suggests a means for making this evaluation. The idea involves the selection of "index areas" which have been subjected to more than ordinary occlusal loads for some time. This approach certainly merits further study. He also suggests a means for improving the stability of bone in edentulous areas which have not been subjected to occlusal loads. The procedure involves the use of treatment appliances which can be converted into dentures. The evidence he supplies supports his suggestion. If this procedure involves bony support for removable partial dentures, a similar improvement might be hoped for in complete denture foundations.

Gerald W. Gaston is to be congratulated on winning the prize for the best essay submitted in the Essay Contest for senior dental students sponsored by the American Denture Society. He discusses many types of occlusal and incisal rest preparations and points out the places where they are indicated.

Arvin W. Mann and Lindsey D. Pankey discuss the theories and concepts which are basic to the use of their diagnostic instrument and describe the technique. This applies a combination of concepts to establish harmonious relationships between the occluding surfaces of the restorations. It is a means for planning the preparation of the natural teeth, so that the minimum alteration of the teeth is required. The occlusal curvature (based on the spherical theory of occlusion) is established by means of the instrument, and this is used for planning and making the restorations for the lower teeth. (The upper teeth are restored later; the technique for this is described in Part II.) Emphasis is placed upon the establishment of an occlusal curvature with which all lower cusp tips make contact. All of the preparations for the lower arch are planned on the instrument before any of them are started, and harmony between the height of the tips of the cusps is assured by making the basic wax

carvings on the instrument. This seems to be a conservative approach to complete oral rehabilitation, and it eliminates irregularities in the height of the teeth in relation to the occlusal curvature.

Lindsey D. Pankey and Arvin W. Mann describe their technique for restoring the upper teeth in harmony with occlusal surfaces previously built into the lower teeth. The important factors of the technique include the use of the lingual inclines of the upper cuspid teeth as controls for the vertical dimension of occlusion, centric relation, and the inclination of the cusps of the posterior teeth. If the lingual inclines of the upper cuspid teeth have been given the proper shape, accurate control of mandibular movement and position is assured. The use of a "functionally generated path" which is controlled by the cuspid teeth will eliminate any interference which might result from the "spherical" occlusal plan built into the lower arch. Thus, if the anatomy of the patient did not correspond to the "theory," the functionally generated path technique would dictate the necessary alterations in the upper teeth. This is an excellent example of a practical technique being developed by combining parts of several techniques in a logical manner.

Jerome M. Schweitzer describes his technique for making gold copings for covering prepared teeth. The copings are cemented permanently to the teeth and can be attached to each other. They can be shaped to achieve parallelism of the preparations, and they make the temporary cementation of fixed partial dentures a safe procedure. These copings should be very useful in many situations.

Arthur Edward Kahn urges conservatism in restorations made in teeth in his discussion of the relative merits of complete and partial coverage. The use of high-speed rotating instruments may lead dentists to use full crowns instead of other, more complicated types of restorations. He suggests some modifications of some of the recognized partial coverage restorations which could increase their usefulness. It is apparent that the type of restoration which would be most beneficial to the patient should be chosen, instead of the type of restoration that is most convenient for the dentist.

Rudolph M. Feuerstein is to be congratulated on the excellence of the essay which won for him the second prize in the Essay Contest for senior dental students sponsored by the American Denture Society. He has made a very complete review of the literature relating to rubber-base impression materials and recommends a technique based upon this information.

—Carl O. Boucher

COMPLETE DENTURES

OVERCOMING OBSTACLES AND OBJECTIONS TO IMMEDIATE DENTURES

LINDELL L. LEATHERS, D.D.S.
Washington, D. C.

NINETY-EIGHT PER CENT of the dentists make immediate dentures at least part of the time.[1] Many dentists do so with reluctance, however, because they feel that this type of denture cannot be made as successfully as one for an edentulous patient. They regard the immediate denture as a temporary denture and do not put forth their best efforts to make it as satisfactory as possible.[2] There is a two-fold advantage in immediate denture service: patients become accustomed to their dentures more readily than do those who have been edentulous and pride becomes a factor in wearing and mastering the dentures.

The immediate denture patient has misgivings concerning the loss of his teeth. By striving to perfect his technique, the dentist will be able to help the patient over the transitional period. There need be no noticeable impairment of appearance or function.

Some of the obstacles and objections which might cause a dentist to avoid making immediate dentures will be discussed.

BORDER-MOLDED IMPRESSIONS

Some dentists use an oversized tray with an alginate (irreversible hydrocolloid), or a similar material, for the final impression for an immediate denture. This procedure results in borders that are overextended and produces unsatisfactory dentures.

A good border-molded impression requires mouth preparations. Study casts and roentgenograms are made before any teeth are extracted. The remaining posterior teeth are extracted about 6 weeks before the impressions are made. During this 6-week period, the appearance is not affected appreciably and about two-thirds of the resorption to be expected within the first 6 to 8 months takes place. The patient can start wearing immediate dentures on firm, well-healed posterior ridges and can masticate more efficiently at the outset. At the time of removal of the

Read before the American Denture Society, Chicago, Ill.

posterior teeth, the mouth should be prepared, also, by the removal of abnormalities such as bulbous tuberosities, tori, or other bony prominences that cause an unsatisfactory undercut relationship (Figs. 1 and 2).

If the patient is wearing a removable partial denture, it must be left out of the mouth for 24 to 48 hours before an impression is made.[3] This period allows the soft tissues to return to normal and avoids perpetuating any tissue distortion.

Fig. 1

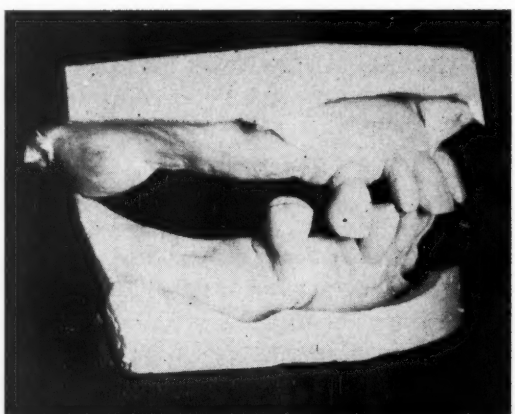


Fig. 2

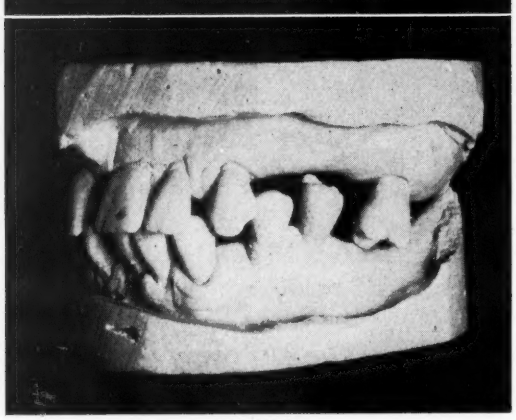
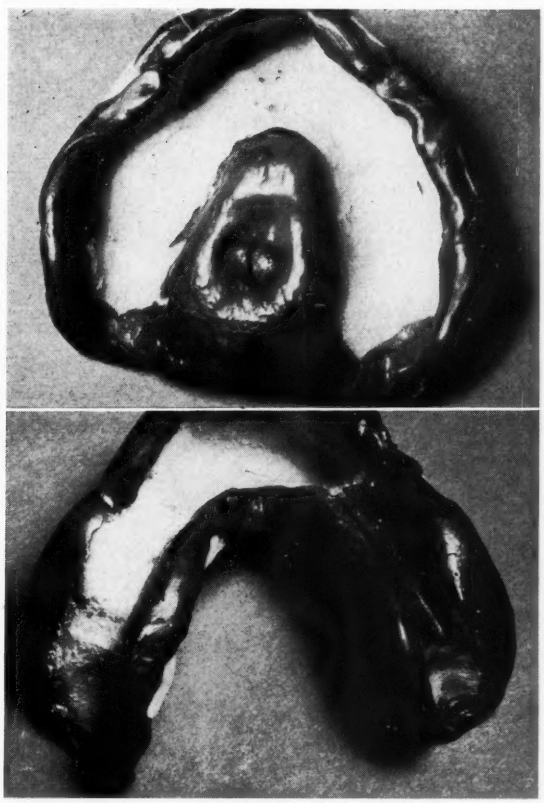


Fig. 1.—Abnormalities are found in mouths where teeth have been lost and are not replaced.
Fig. 2.—The teeth and bone have migrated, leaving insufficient space for the artificial teeth.

Specially designed stock trays can be used in making impressions for immediate dentures. The work is simplified, however, if an irreversible hydrocolloid impression is made in a stock tray, casts are poured, and an individual tray is constructed of a self-curing resin with a spacer of wax or asbestos. The borders of the individual tray are purposely made a little too short. A low-fusing modeling compound is used to form a stop over the posterior part of the lower ridge and over the palatal and posterior parts of the upper ridge.

All of the borders of the individual trays are border molded and their proper thickness is developed with low-fusing stick modeling compound (Fig. 3). The distobuccal part of the upper flange is molded so that it allows room for ordinary movements of the ramus of the mandible. This procedure is accomplished by having the patient move the mandible to the side opposite the flange being molded.

A.



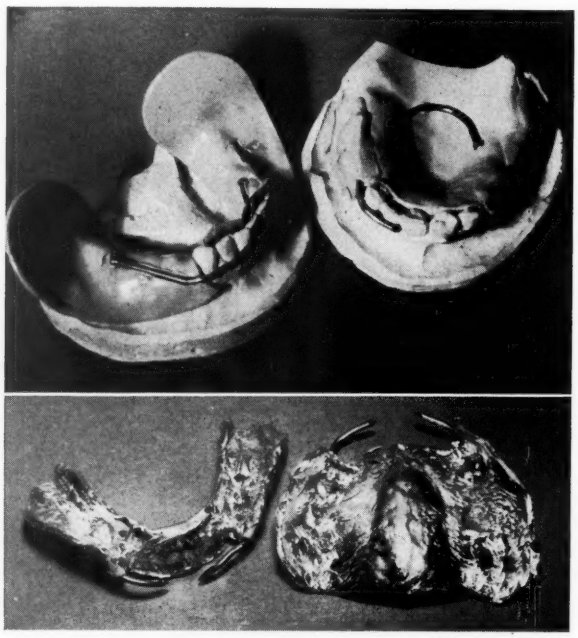
B.

Fig. 3.—*A* and *B*, Modeling compound is used as a stop in the palate of the upper and the posterior part of the ridge of the lower individual tray. The trays are border molded with low-fusing modeling compound.

Modeling compound is added over the posterior palatal seal area to create good contact with the soft palate. Since the final impression is made in alginate, it is imperative that a certain thickness of the alginate is maintained to provide accuracy and to prevent tearing the impression material. Certain parts of the tray are reduced 0.5 to 1.0 mm. by scraping. These are (1) the distobuccal flange and the part of the upper tray in approximation with the zygomatic process of the maxilla, (2) the lingual surface of the lingual flange of the lower tray, and (3) the part of the lower tray that covers the retromolar pad.

The inside of the tray is prepared so that the impression material will not pull away from it. Except for the borders, the entire surface of the modeling compound is scarified with a sharp knife. Then chloroform is put on the surface, followed by cotton which is pulled over the resultant tacky surface. The anterior teeth are free from any contact with modeling compound. When the alginate impression is made, it may be overextended at the borders, but by cutting off the excess material at the inside curvature, the original border will be preserved.

A.



B.

Fig. 4.—*A* and *B*, Metal clasps are used to prevent shifting of the baseplates during registration of maxillomandibular relations.

Master casts are poured from these impressions (on a metal index), and, as soon as the stone has set thoroughly, a second set of casts is made from the same impressions. The extra casts are valuable for studying the duplication or changes necessary or desirable in the finished dentures.

MAXILLOMANDIBULAR REGISTRATIONS

Accurate maxillomandibular registrations can be obtained while the anterior teeth are still in place. Shellac baseplates are adapted to the casts, kept out of undercuts, and lined with zinc oxide and eugenol impression paste interposed between tin foil and the baseplates. A semirigid metal (such as a finishing nail) is contoured to engage the labial surfaces of the anterior teeth close to the gingivae. The metal is extended onto the baseplate covering the ridges and is attached by an additional

covering of baseplate material (Fig. 4). These metal prongs engaging the teeth stabilize the baseplates. This is an advantage only possible in immediate denture construction. The upper cast is oriented on the articulator by means of a face-bow transfer.

A smooth, hard, stainless alloy plate is secured with modeling compound to the palatal part of the upper baseplate, and a plate with a slightly blunted central bearing point is attached with modeling compound to the lower baseplate. The central bearing point is adjusted to provide the proper vertical opening. This adjustment allows enough horizontal space between the upper and lower anterior teeth so that a Gothic arch tracing can be made by the central bearing point. If there is not enough space between the anterior teeth for lateral jaw movements to be made,

Fig. 5

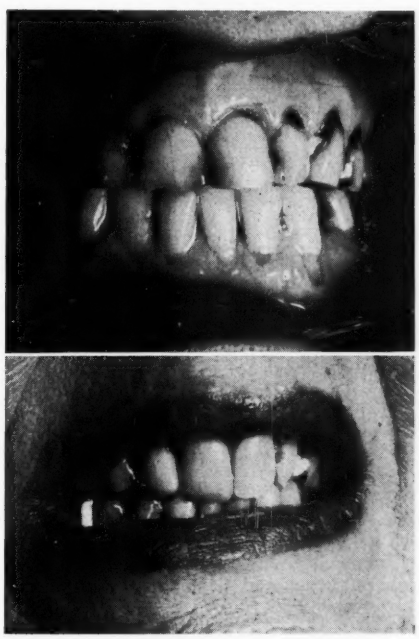


Fig. 6

Fig. 5.—The teeth have been reduced approximately 2 mm. by incisal wear. Therefore, increasing the vertical dimension of occlusion affords sufficient clearance for lateral jaw movements and permits the making of the Gothic arch tracing.

Fig. 6.—The vertical overlap and the contact of the anterior teeth in centric relation necessitated grinding to make clearance for lateral jaw movements.

the teeth on the casts are trimmed to create this space and the patient's natural teeth are ground accordingly (Figs. 5 and 6). The purpose and result of this procedure are explained to the patient. Usually, the wear on the natural teeth enables the vertical dimension of occlusion to be opened from 0.5 to 1.0 mm., but, if more space is essential, the labioincisal edges of the lower teeth and the lingual surfaces of the upper anterior teeth are ground.

A Gothic arch tracing is made, and the relationship between the baseplates is fixed with plaster.[4,5] The locked registration is removed from the mouth, and the upper and lower rims are separated so that the plaster remains on the lower baseplate with its central bearing pin. Any plaster touching the teeth is trimmed away, and the baseplates, along with the plaster interocclusal record, are placed on the stone casts. The plaster around the central bearing pin is cut away, and indelible ink is placed on the point of the pin. The upper and lower assembly is fitted together again, then separated, and if the indelible ink has been transferred to the apex of the Gothic arch tracing (which was made by the central bearing point), the correct centric position is verified (Fig. 7).

The casts, baseplates, and tracing assembly are locked together with wooden sticks or nails luted to the stone casts with sticky wax or modeling compound. This assembly is mounted on the articulator. A protrusive registration is obtained with plaster, and the condylar guidances are set. The indelible ink check is used to indicate the amount of protrusion.

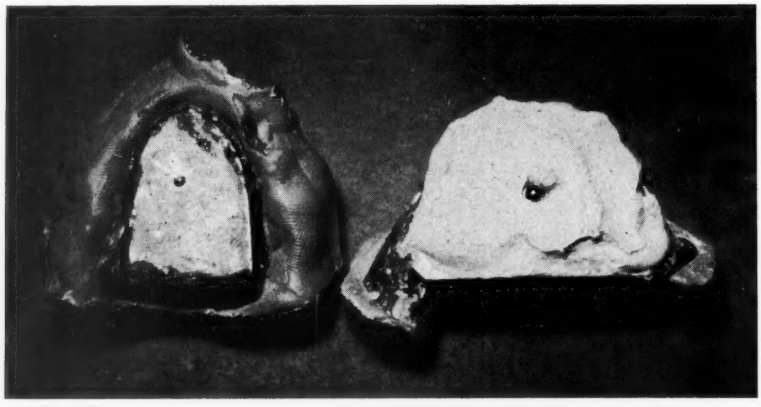


Fig. 7.—The accuracy of the centric and protrusive relation is verified by the use of indelible ink on the point of the central bearing pin. The plaster is cut away from the pin to avoid blurring the record.

TOOTH ARRANGEMENT

Even though the anterior teeth may have required trimming, the duplicate casts are available so that measurements can be made from the mucolabial fold to the incisal edge of each tooth. However, since the anterior teeth should not touch when the mandible is in centric relation, modifications are usually made to allow freedom for excursive movements. This can be accomplished by several means. The labial surface of the lower anterior teeth can be either shortened or shortened and beveled toward incisal edges of the teeth. The upper anterior teeth can be set so the incisal edges are 0.5 mm. labial to the position of the natural teeth. These compromises are so slight that they will not be detected in the finished dentures.

Patients should be acquainted with the aims and problems of immediate denture construction. The use of the master and duplicate casts should be explained to them. The patient and other members of the family should see the final arrangement of the teeth[6] and understand the means used to bring about the best possible arrangement. By using the two sets of casts, measurements can be made from the mucolabial folds to verify the positions for the location of all the anterior teeth.

If the anterior teeth were placed in exactly the same position in relation to the ridge as the natural teeth, approximately 1.0 mm. of the gingival third of the artificial tooth would be covered by base material. The result would be noticeable immediately, and the teeth would appear shortened at their gingival ends. More of the denture base than desired would show, and there would be an undesirable plumping effect. If the teeth were butted against the crest of the ridge and no labial flange were used, most of the retention of the upper denture would be lost and an unsightly space would appear between the teeth and the ridge as the shrinkage began.

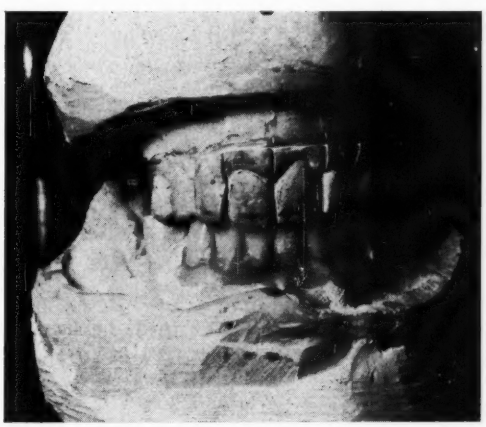


Fig. 8.—The casts are marked to indicate the correct trimming of the ridge and placement of the artificial teeth.

By the time the patient loses his teeth, some bone resorption has usually occurred. Roentgenograms will determine the relationship of the enveloping bone to the teeth. Whether or not the bone has resorbed, however, it is advantageous to select anterior teeth that are about 1.0 mm. longer than the natural teeth. Thus, the denture base will not cover the teeth any more than the gingivae in the natural dentition (Fig. 8).[7] Consequently, the ridge should be trimmed conservatively about 1.0 or 2.0 mm. to provide a more esthetic result. Any changes made in the ridge of the master cast are made also on the duplicate cast as a guide to the oral surgeon. Templates are not used because they become covered with blood so quickly that they are not effective in locating the tissue to be trimmed. Before processing the dentures, the posterior palatal seal area must be re-established by scraping the master cast.

Immediately after processing, the dentures are remounted on the articulator and the occlusion is checked and adjusted.

PREADJUSTMENT AT INSERTION

The question of whether the patient will experience much discomfort with an immediate denture is important to both the patient and the dentist. Careful planning and cooperation between the oral surgeon and the prosthodontist in scheduling their appointments are necessary to maintain the good will of the patient. In order to preadjust the new dentures, the patient should be required to return to the prosthodontist immediately following the extraction of the anterior teeth. In order to locate any impingement of the tissue by the dentures when they are inserted or removed, and to do this painlessly, the oral surgeon must administer a long-lasting block anesthesia (from 4 to 8 hours' duration) before dismissing the patient. This is done regardless of whether a general or local anesthetic had been used for the operation. Block anesthesia is desirable so that the tissues are not distended at the tissue reflections, and only a small amount of anesthetic should be used at the incisive foramen for the same reason.

Two materials, each with specific advantages in certain places, are used for testing the dentures. One is a disclosing wax, and the other is a silicone paste. The latter should never be used in slight undercuts, because it smears and the indication of the undercut is obliterated.

The patient is dismissed after the pressure spots are relieved and after he has received special instructions concerning his immediate comfort. He is given a powder,* which consists of one-third penicillin and sulfa in combination with two-thirds denture adhesive powder, for use inside the anterior portion of each denture. The powder prevents infection, cushions the tissues, and gives the patient a feeling of security in the retentiveness of the dentures until he learns to handle them. The patient is instructed to remove the dentures four times daily (after each meal and at bedtime), to rinse his mouth with a solution of warm water and baking soda (no salt), and to rinse the dentures and place fresh penicillin and adhesive powder inside them. He is given a prescription for ½ grain codeine to minimize the discomfort from the operation. At an appointment the following day, his mouth is checked for any undue pressure that may have occurred. When the dentures are adjusted in this manner at the time of insertion, they serve as a protective splint and the patient will find that he is more comfortable with than without the dentures. The detailed attention given the insertion of the dentures greatly enhances the dentist's relationship with the patient.

After 4 to 6 weeks, almost three-fourths of the shrinkage which will take place over a period of from 6 to 8 months has occurred. At this time, an autopolymerizing relining material can be added inside the dentures as a temporary measure. This enables the patient to get along satisfactorily for the remainder of the time the ridges are changing and until the condition of his mouth is such that final rebasing or reconstruction of the dentures can be done.

*Formula: Powdered penicillin G potassium, 1,000,000 units; sulfanilimide, 50 Gm. Mix in 3 oz. bottle, then combine this mixture with any commercial denture adhesive powder in a ratio of 1 part of the mixture to 2 parts of the adhesive powder.

CONCLUSION

When the obstacles and objections to immediate dentures are handled properly, they need not present problems of any consequence and may even be turned into advantages. In overcoming these problems, we create educated, understanding, and appreciative patients and will be rewarded by their continuing cooperation and confidence.

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IMMEDIATE DENTURE PROSTHESIS

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IMMEDIATE DENTURE SERVICE is usually both desirable and indicated for patients who must lose their remaining teeth. Present materials and techniques provide vastly improved general denture service and immediate denture service, in particular.

The immediate denture serves as much more than a steppingstone between extractions and a "temporary denture." A temporary denture is constructed as soon as it is discovered that the immediate denture does not fulfill the requirements of function and esthetics. A patient may maintain an immediate denture for long periods of service, however, without any pathologic changes of the ridge or border tissues. Hooper[1] states that the patient who is about to lose his natural teeth is usually concerned about the probable results. Schlosser[2] states that immediate dentures are indicated for practically all patients, if age and general health permit. Swenson[3] feels that immediate denture construction must be planned to give the patient long-range service.

The psychologic impact is great when the patient is confronted with the loss of his remaining teeth. He can recover quickly from the emotional shock of losing the teeth, however, if esthetic appearance and masticatory functions are regained. In sensitive patients the reaction is quite acute, and these patients must be provided with an adequate, immediate substitute for their natural teeth. Some men associate the loss of their remaining teeth with a loss of virility. Many women associate it with reaching old age. The dentist must explain that these apprehensions are not founded on fact but are based on fantasy. Visual charts, photographs, and casts of previous immediate prosthetic replacements are available, and if these are explained properly the fears of the patients can be allayed.

If the denture does not restore function, facial contours, and proper tooth positions, a serious psychologic situation may arise. The initial denture experience of many patients is a serious one; the dentist cannot treat this phase of prosthodontics lightly.

ADVANTAGES OF IMMEDIATE DENTURES

Some of the advantages of immediate dentures are: (1) they prevent the embarrassment of being edentulous, (2) they prevent loss of vertical dimension and muscle tone, and avert disharmony of the muscles of facial expression, (3) centric

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relation can be recorded more accurately, (4) the patient can adjust to a denture more easily, (5) the esthetic requirements are satisfied more easily because the remaining teeth serve as guides for proper tooth arrangement, (6) postoperative bleeding and pain are controlled better because the denture serves as a bandage and prevents contact of food with the tissues, and (7) speech and deglutition may not be impaired.

CONTRAINDICATIONS TO IMMEDIATE DENTURE SERVICE

There are contraindications to immediate denture service when (1) the age is such that multiple extractions would subject the patient to undue strain, (2) the physical condition is such that multiple extractions might cause a serious postoperative illness, or (3) the patient does not desire this service.

Fig. 1.—The natural anterior teeth are an integral part of immediate denture construction and may be incorporated in the denture.

DIAGNOSIS AND TREATMENT PLANNING

Many immediate dentures are constructed with improper diagnoses and ill-planned treatment schedules. These dentures usually are unsuccessful despite the application of excellent technical procedures. The diagnosis for an immediate denture is the same as that for a complete denture, but with some added precautions. Those additional diagnostic points consist of the determination of: (1) what changes, if any, should be made in the vertical dimension, (2) what teeth should be extracted before impression making, (3) what changes, if any, should be made in the existing tooth arrangement and arch form, (4) whether an unfavorable vertical overlap should be corrected, and (5) whether an excessive horizontal overlap should be corrected.

Since balanced occlusion in centric position and, if possible, in lateral and protrusive excursions is important in immediate dentures, it is mandatory to have a full or nearly full complement of opposing teeth. The teeth may be artificial or natural or a combination of both. The necessary repair or replacement of the opposing teeth is completed before the immediate denture is processed, so that it is easier to check centric relation. Both the upper and lower prosthetic replacements are placed in the mouth at the same time.

The final diagnosis is made by a careful evaluation of the clinical and roentgenographic examinations of the patient. The patient should be made aware of any problems before treatment. Treatment planning is scheduled so the patient and dentist will know the time of starting and completing the prosthesis. The dentist plans the type of anterior and posterior tooth replacement, considering the possibility of using the patient's natural teeth in the denture (Fig. 1).

IMPRESSIONS

The immediate denture patient may have some or all of the posterior teeth missing. If posterior teeth are present, they are removed before the impression is made.

Impressions for immediate dentures must be accurate. The rules that apply to impression making in an edentulous mouth apply to the immediate denture impression.[4] The presence of teeth makes the impression a combination complete and partial denture impression. The borders of the preliminary impression fill the vestibules to their full height and width. The final impression should be the exact negative record of the tissue to be covered by the denture, with a posterior extension approximately 3 mm. beyond the pterygomaxillary notches and the vibrating line.

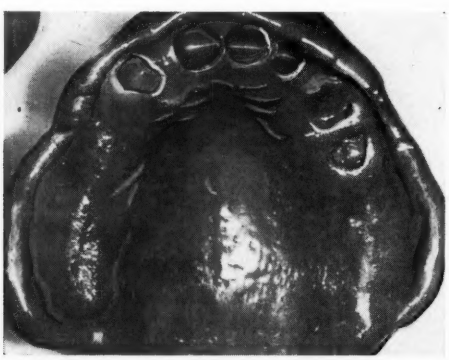

Fig. 2.—A thiokol, rubber-base material is used for the final impression.

I will describe my impression technique[5] assuming that no posterior teeth are present and the posterior ridge tissue is healed. I select an impression tray with flanges short enough that they will not impinge upon the easily displaceable border tissues. Two cakes of medium-fusing modeling compound are softened in a compound heater, and the softened mass is placed inside the tray. The compound is luted to the tray with dry heat from an alcohol torch. The initial seating should be for centering and distribution of the compound. The impression is removed from the mouth *unchilled*. When the anterior teeth are very loose, I pack the interproximal spaces with a soft wax so that the modeling compound will not pull on the teeth when the impression is removed. The impression is chilled outside the mouth, and modeling compound in the region of the remaining anterior teeth is scraped away so that the tray can be reseated without difficulty. The dried tissue surface of the modeling compound is flamed with an alcohol torch, the compound is tempered in

the compound heater in water at 160°F., and the tray is reseated. The impression is removed, and the borders are completed with low-fusing stick modeling compound. The usual muscle movements to form the borders are performed by the patient. The border should be complete and include the anterior or labial segment.

The cast is poured in stone in such a manner that the borders are definitely preserved. A generous amount of lead relief metal is cemented to the area around the teeth and a cold-cure, acrylic-resin tray with a short handle is made.

The acrylic-resin tray is tried in the mouth and adjusted carefully. The frenal attachments are relieved and any overextensions are removed. Underextensions are corrected with stick modeling compound.

The final impression is made with a thiokol, rubber-base impression material (Fig. 2). The tissues are dried as much as possible before the loaded tray is inserted and jiggled into position with a minimum of pressure. The soft tissues of the borders and the bearing area should not be displaced. The usual muscle movements for developing a proper border roll are executed by the patient. The impression is boxed and carefully poured in stone.

TRIAL DENTURE STAGE

A cold-cure, acrylic-resin trial denture base is constructed on the "master" cast. The base covers the tissue posterior to the remaining anterior teeth. Hard wax occlusion rims are attached to the base in the edentulous areas.

A face-bow record is made and the cast is attached to the articulator. The vertical dimension is established in conjunction with the centric relation record. The wax rim is trimmed until the facial measurement shows a 2.5 to 3 mm. interocclusal distance when the mandible is in the physiologic rest position. A single thickness of baseplate wax is luted to the occlusal surface of the wax occlusion rim. The wax rim is heated carefully by means of an alcohol torch. The occlusion rim is placed in the patient's mouth, and he is told to close on the "back" teeth without force. The occlusion rim is removed and the wax is chilled.

The posterior palatal seal is established by the indirect method. The lower cast is mounted by means of the interocclusal centric relation record. In this example, there is a full complement of lower teeth. The posterior teeth are set up using the correct mold and occlusal type, as indicated by the lower teeth.

The trial denture is placed in the patient's mouth, and the vertical dimension is rechecked. It may be necessary to use an adhesive powder to hold the upper trial denture base in position for this observation.

If the vertical dimension is correct, the centric relation record is verified by means of an interocclusal wax record. Two thicknesses of hard baseplate wax are luted to the *dry* posterior teeth. Then the alcohol torch flame is directed over the surface of the wax, the flame moving from side to side, until the heat penetrates the full thickness of the wax. The trial denture is inserted quickly into the mouth, and the patient is told to *close* without force on the posterior teeth. The thumb and forefinger of the right hand are placed lightly on the tip of the chin, and the patient's mandible is guided into the retruded position if he cannot retrude it without help. The closing pressure should not be enough to cause the teeth to penetrate the wax. The wax is chilled by a cold-water spray, the trial denture is removed, and

the excess interproximal, buccal, and lingual fins of wax are cut away with a scalpel. The wax is dried and softened by dipping it in a water bath at 138°F. for a few seconds. A new centric relation record is made, then the wax is chilled and the trial denture is removed and placed on the mounted upper cast. When the articulator is closed, the lower teeth must fit perfectly into the shallow indentations in the wax (Figs. 3 and 4). No compromise is permissible when centric relation is being verified. The lower opposing teeth must fit perfectly into the interdentations

Fig. 3

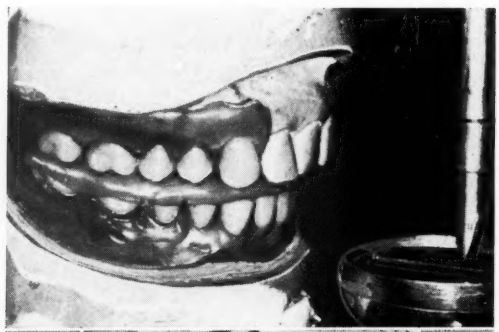

Fig. 4

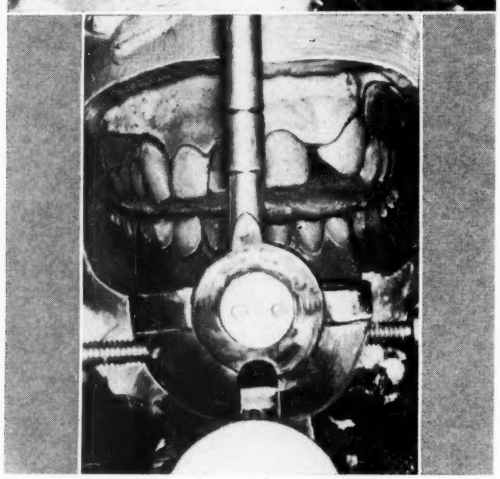

Fig. 3.—The centric relation mounting is verified by means of an interocclusal wax record.
Fig. 4.—The teeth must fit the record perfectly or the mounting is considered incorrect.

while the condylar balls of the articulator are snug against the condylar stops. If the centric relation mounting is incorrect, the lower cast is removed from the articulator and is remounted by means of a new wax interocclusal record. Another wax record is made, and if this checks the mounting is accepted. No record is more important than the centric relation record. A great deal of care is necessary to verify it.

Next, a wax interocclusal protrusive relation record is made. The condylar inclinations are adjusted to the protrusive record, and the condylar posts are set according to the Hanau formula.

The posterior teeth are arranged for balanced occlusion in the centric and eccentric positions (Fig. 5). Frequently the position of the anterior teeth prevents ideal balanced occlusion at this stage of construction. Sometimes a slight modification of the incisal edges of the upper anterior teeth on the cast, either by shortening or beveling, is sufficient to achieve protrusive and lateral occlusal balance. If the patient's own teeth are to be used, they must be trimmed in exactly the same manner after removal.

Many patients with teeth which have migrated because of periodontal disease or with untreated orthodontic problems desire immediate dentures. Others have severe prognathic or retrusive ridge relationships. It is foolish to set the artificial teeth in a "normal" arch form and position for these patients. The finished results are rarely esthetic and must be discarded immediately. The dentist should place the artificial teeth in the same position, or close to it, as the natural teeth were in the

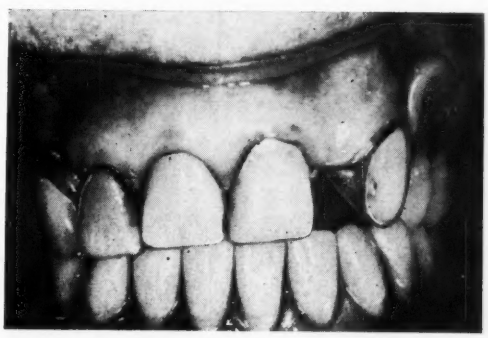

Fig. 5.—The posterior teeth are arranged for balanced occlusion on the trial denture base.

patient's mouth. Stability and retention can be maintained without subsequent injury to the supporting tissues, provided centric relation and centric occlusion are in harmony and the patient can continue oral functions as he did previously. The posterior teeth should be in maximum occlusal contact in centric relation and there should be no interferences in lateral and protrusive excursions if possible. Pathologic and traumatic tooth positions may be corrected with a second denture, where a try-in is possible.

WAXING THE TRIAL DENTURE

After the posterior teeth have been properly arranged, the denture is ready for waxing. The usual procedures are followed with the additional step of waxing a labial band above the level of the anterior teeth. The band connects the posterior flanges of the denture. Before this wax is added, a strip of relief metal is placed in the area of the "band." It extends distally just past the last teeth on each side and from a line 3 mm. above the gingival margin to a line 2 mm. below the reflection. The relief metal allows enough space for the finished denture to be seated without impingement on the tissues in this region.

PURPOSE OF THE ANTERIOR BAND

This band of acrylic resin is joined to the denture to facilitate the holding of the anterior teeth which are to be added at a subsequent visit. There is a void in the anterior region at this time. The posterior part of the denture and the labial band are processed.

Fig. 6

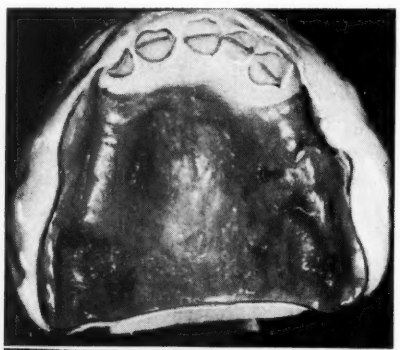

Fig. 7

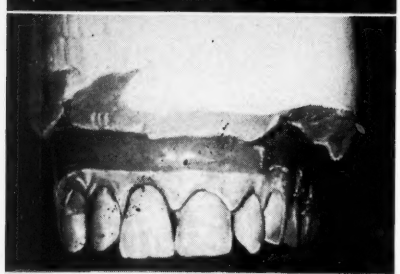

Fig. 8

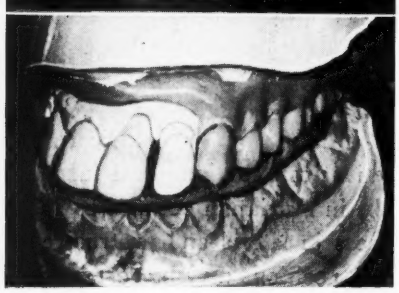

Fig. 6.—The final impression is made after the posterior part of the denture has been processed, and this part is included in the impression.

Fig. 7.—The partially completed denture is mounted with the final cast. Note the labial band of acrylic resin.

Fig. 8.—The mounting of the final cast is verified with an interocclusal centric relation record.

TRY-IN OF PARTIALLY COMPLETED DENTURE

The partially completed denture is finished, polished, tried in the patient's mouth, and adjusted to go into place around the remaining teeth. Then the final impression and cast are made.

A perforated tray is selected. The anterior flange of the tray must not be above the band of resin which connects the posterior flanges. A ball of heated modeling compound is placed in the mid-palate part of the tray, and the tray is placed in the mouth and seated over the partially completed denture until the anterior border of the tray is 3 mm. below the labial reflection. The modeling compound acts as a stop and prevents any possible movement of the denture while the impression is being made. It also prevents impingement of the tray upon the anterior border tissues.

An alginate impression material is mixed and placed with the forefinger in the anterior mucobuccal fold. The remaining portion of the mix is placed in the tray, and the tray is seated until stopped by the modeling compound. The patient executes the usual facial movements to border mold the anterior segment of the impression. After three minutes the impression is removed, with the denture usually in place (Fig. 6). If the denture does not become dislodged, it can be removed and fitted accurately into the impression. A hard stone is used for the final cast (Fig. 7).

The new cast holding the partially completed denture is now mounted on the articulator so that the posterior occlusion can be perfected before the removal of the remaining teeth. The mounting is made by means of a wax interocclusal centric relation record. The lower cast remains on the articulator to preserve the face-bow record. When a removable partial lower denture is made in conjunction with an immediate upper denture, the partial denture is finished first. Then a cast is made of the lower denture in position and the upper denture is mounted against this.

The new upper cast mounting is verified by the same procedure that was used for the trial denture (Fig. 8). The dentist must make the necessary corrections of the occlusion in centric and eccentric positions. When the occlusion has been perfected the anterior teeth are added to the denture (Fig. 9).

If the patient's natural teeth are to be used an index is made on the final cast. A light lubricant is placed on the labial surfaces of the anterior stone teeth, and a stone matrix is made to include the incisal edges, the labial surfaces of the teeth, and the labial flange including the anterior resin band (Fig. 10). The matrix is removed carefully and laid aside.

SURGERY

The anterior teeth are removed carefully so as not to remove the buccal plate of cortical bone. The interseptal bone is removed, and the buccal and lingual plates are compressed by finger pressure. The sharp gingival bony points are smoothed. The interseptal gingival soft tissue and the margins of the buccal and lingual soft tissue flaps are removed carefully with scissors (Fig. 11), and the wound is sutured. The extracted teeth should be kept in normal saline solution during the postextraction operation if they are to be included in the denture.

SETTING NATURAL ANTERIOR TEETH

The natural teeth must be prepared properly for use in an immediate denture. First, the root is cut off so that it will fit into the matrix exactly (Fig. 12). If the tooth crown is too long the matrix will not be seated, and if it is too short

Fig. 9

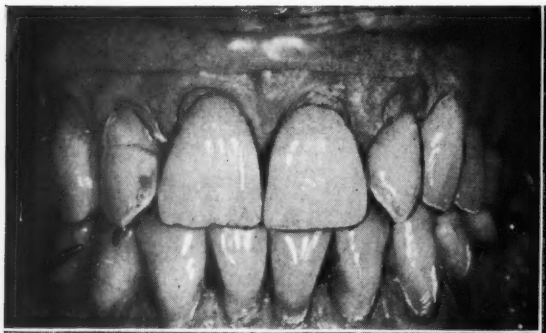

Fig. 10

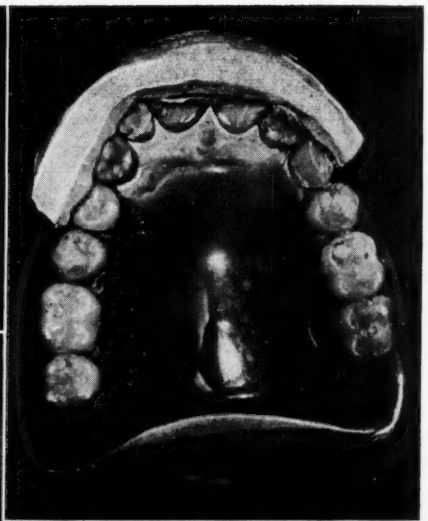

Fig. 11

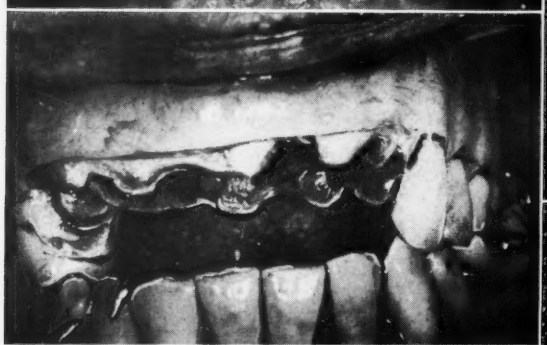

Fig. 12

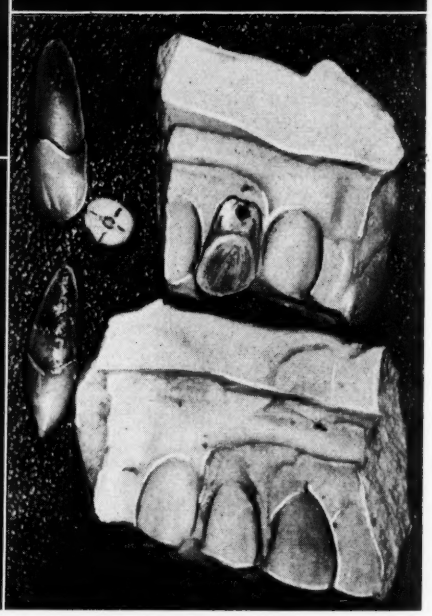

Fig. 13

Fig. 9.—Selective grinding on the posterior teeth is completed and the occlusion is checked in the mouth.

Fig. 10.—A stone matrix is used to position the natural anterior teeth on the denture.

Fig. 11.—The anterior teeth have been removed and the posterior part of the denture is in place. Note the anterior band of acrylic resin.

Fig. 12.—The extracted teeth are prepared for use in the denture. They are cut to the correct length and the pulp chamber is undercut and filled with cold-cure acrylic resin.

Fig. 13.—The natural teeth are attached to the palatal part of the denture base with cold-cure acrylic resin.

too much resin will show on the labial surface of the denture. Second, the severed crown is undercut with a No. 37 inverted cone bur. Third, the pulp chamber is cleaned out, dessicated with alcohol, and filled with tooth-colored, cold-cure acrylic resin. The tooth is never allowed to become dried for long periods of time.

The first tooth selected to be replaced is cut off the stone cast, and the socket is prepared as usual in the immediate denture technique. The prepared natural tooth is placed in the stone matrix, and the matrix is placed in position on the cast. Cold-cure acrylic resin is used to attach the natural tooth to the palatal portion of the denture (Fig. 13). If the six anterior teeth are to be replaced, the order of placement should be left cuspid, right cuspid, left central incisor, right lateral incisor, left lateral incisor, and right central incisor. When all of the anterior natural teeth

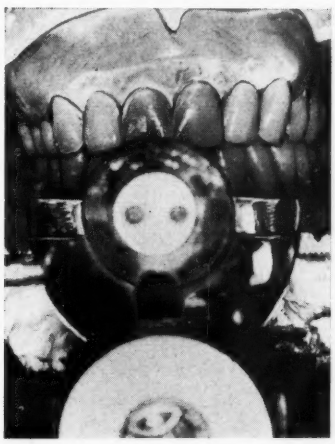

Fig. 14.—Artificial anterior teeth may be ground to shape and arranged in the correct positions.

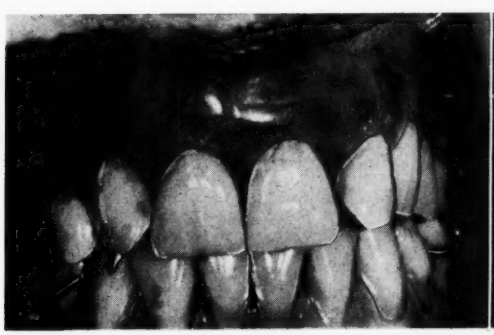

Fig. 15

Fig. 16

Fig. 15.—An immediate denture completed with natural anterior teeth is in place in the mouth.

Fig. 16.—An immediate denture completed with artificial anterior teeth is in place in the mouth.

have been so attached, the entire assembly, with the matrix in position, is placed in warm water for a few minutes. The denture is then removed from the cast and placed again in a warm water bath while the cast is prepared for the formation of the labial flange.

SETTING ARTIFICIAL ANTERIOR TEETH

When artificial anterior teeth are used, the usual method of replacing each tooth is followed (Fig. 14). It is easy to attach the artificial teeth to the denture with cold-cure resin as they are set into position. The entire assembly is immersed in a warm water bath for five minutes to harden the added resin.

Then, the denture is removed from the stone cast and the cast is prepared for the addition of the labial flange. Final selective grinding and milling are done *after* the anterior flange has hardened.

ADDING THE ANTERIOR FLANGE

The sharp, interproximal buccal and lingual fins of stone are smoothed carefully with a knife or fine abrasive wheel. The area of the operation is covered with 0.001 gauge tin foil. Regardless of whether natural or artificial teeth are used, the anterior flange is added in the same manner. Thus, the fixation of the anterior teeth to the denture and to the immediate denture is completed.

The denture is placed again on the prepared final cast, and cold-cure acrylic resin is poured onto the foiled part of the cast to engage the natural teeth anteriorly. The resin is made to flow under the cured band of acrylic resin in the anterior region, to the reflection on the cast. The acrylic resin lingual to the teeth is reinforced with the new mix of resin if necessary. The same polymer as was used for the original denture is used but with a cold-cure, cross-linked monomer. When sufficient resin has been added, the assembly is placed in a warm water bath for ten minutes to harden. The added resin is polished. When the immediate denture is inserted into the patient's mouth, esthetics and function have been restored (Figs. 15 and 16).

CONCLUSION

A technique has been described which permits the development of occlusal harmony before the anterior teeth are removed. This technique makes it possible to use desirable natural anterior teeth in immediate dentures.

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CONTOUR CHANGES OF THE ALVEOLAR PROCESSES FOLLOWING EXTRACTIONS

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THE CONTOURS of the alveolar processes undergo continuous changes following tooth extractions, because bone resorption and subsequent structural rearrangement occur. These changes are in accordance with Wolff's law, which states that every change in the function of bones is followed by definite changes in their internal architecture and in their external shape.

Craddock[1] states that resorption of bone following tooth extractions takes place in two phases. The early resorption is part of the healing process and takes place very rapidly. The second phase is the inevitable resorption that goes on indefinitely.

The various factors that govern bone resorption have been discussed.[2-7] Little has been reported, however, on actual recording of bone resorption following tooth extractions[8,9] to determine the rate and distribution of the resorption process. Such information would be of value in planning clinical and technical dental procedures for immediate denture construction. Some prediction of the effective life of a denture built on a plastic, bony foundation would be possible, and the timing of corrective procedures could be based upon an expected rate and distribution of resorption.

This study was therefore designed to provide information on the rate and distribution of alveolar contour changes following tooth extractions. The changes were studied in both the vertical and horizontal planes.

METHODS

Subjects were selected from a group of 20 patients whose maxillary anterior teeth were to be removed. The posterior teeth were intact. Recordings were made on 3 of these subjects.

The 3 subjects were Chinese women, 15, 19, and 31 years of age, respectively. They were physically fit, with no history of debilitating diseases and no clinical signs of periodontal disease. Roentgenograms showed healthy, "normal" bone. The blood was also normal. Calcium levels were from 9 to 11 mg. per cent, phosphorus 4 to 5 mg. per cent, and alkaline phosphatase 2 to 4 Bodansky units.

When the teeth were removed submucosal local anesthesia was used. Extreme care was taken to minimize trauma to gingival tissues and underlying bone by reflecting the epithelial attachments prior to extractions. Bleeding was brought under control before the patient was dismissed.

Fig. 1

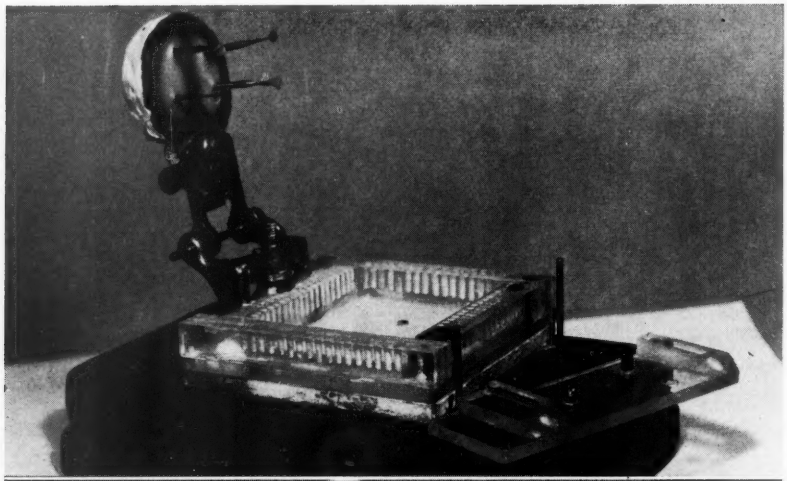


Fig. 2

Fig. 3

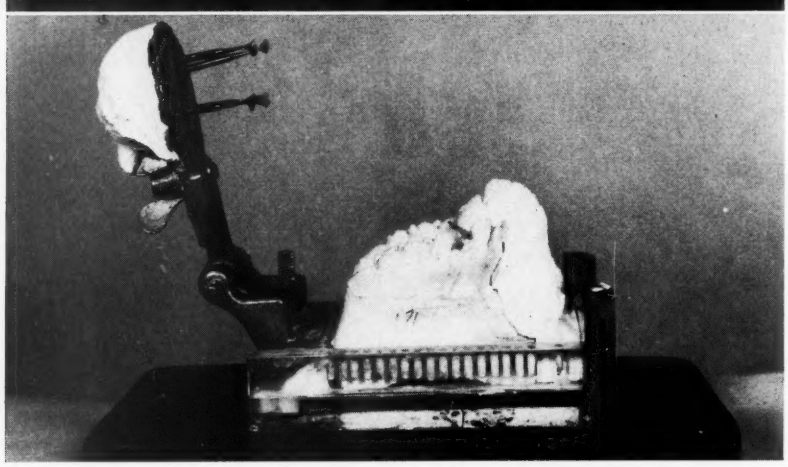


Fig. 1.—An orienting appartus permits accurate mounting of successive casts in the same position.

Fig. 2.—The acrylic resin cups on the steel mounting rods fit over cusps and establish a plane of orientation for each series of casts.

Fig. 3.—Plaster forms are poured over the tissue under investigation.

The subjects were examined at regular intervals beginning the day after the extractions, weekly for 1 month, then monthly for a period of 8 months. A final visit was 1 year from the date of extractions.

Impressions were made before the extractions and at each subsequent visit. A nonpressure impression method was used and standardized as to the use of trays, impression material (alginate), powder-water ratio, mixing time, etc. Casts were poured immediately in artificial stone, also with standardized powder-water ratio and mixing time.

The pre-extraction casts for each patient were provided with a plaster of Paris (nonexpanding) base poured upon the acrylic resin base of the orienting apparatus (Fig. 1). The plane of occlusion was horizontal, and the part of the cast under investigation was placed on the side opposite the movable arm of the

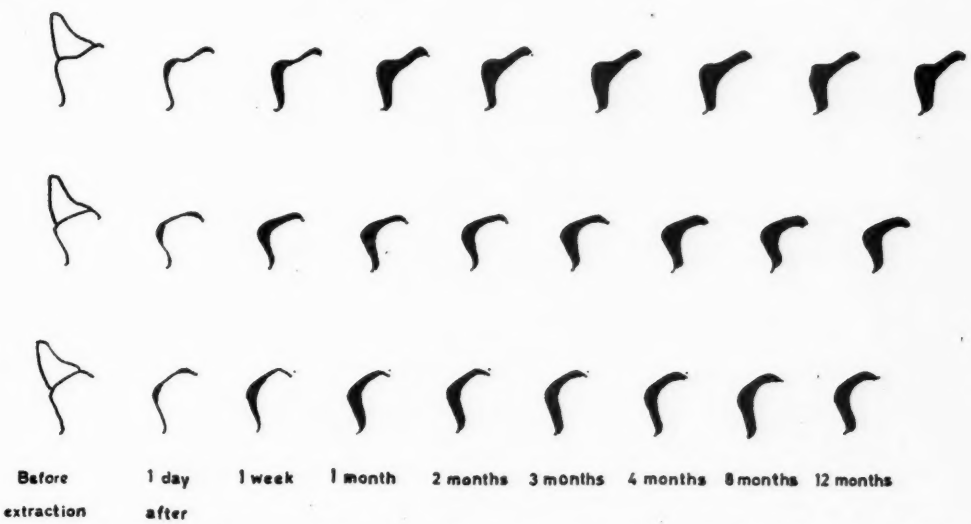


Fig. 4.—The tracings provide a progressive picture of tissue resorption that has taken place over a period of one year.

apparatus. This position of orientation was maintained throughout the series, being reproduced at each mounting of the other casts of the series by means of the mounting rods. These rods are rigidly fixed to the removable arm by plaster of Paris, and the free ends hold acrylic resin cups that accurately fit four selected cusp tips of the cast to be measured (Fig. 2). The position of all casts of one series was thus standardized.

Plaster of Paris (nonexpanding) forms were poured over the areas under investigation (Fig. 3) and were later sectioned at predetermined locations. A tracing of each section was made on graph paper, and by carefully superimposing consecutive tracings upon the pre-extraction tracing an over-all, progressive picture of tissue contour changes was produced (Fig. 4). Extreme care was taken in the sectioning and in tracing the contour outlines. Since all plaster forms fit the same standard bases, it was simple to superimpose subsequent tracings directly upon the pre-extraction tracing (Fig. 5).

Removable partial immediate dentures with socketed artificial anterior teeth were inserted and checked carefully for pressure contact on the underlying tissues. Regular recall checks were made.

RESULTS

The healing following the extraction operation was without complications. Epithelium covered the tooth sockets in 7 to 9 days.

After the first 2 weeks a space had developed between the ridge laps of the artificial teeth and the ridge. The space was larger at the end of the first month (Fig. 6). A labial flange was added to the denture at the end of this period.

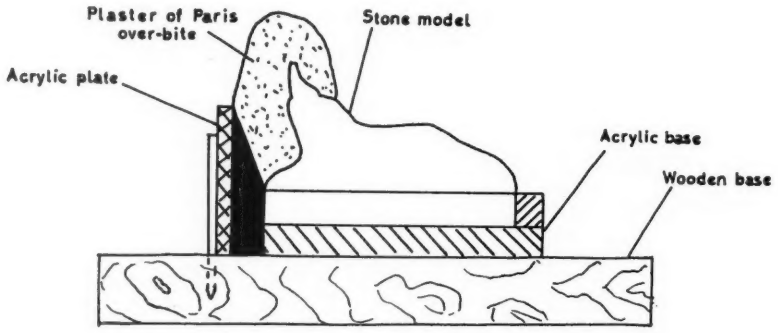


Fig. 5.—The plaster of Paris form is in position. The darkly shaded base in used as a tracing index for production of tracings as seen in Fig. 4.

Fig. 6.—A space develops between the artificial tooth and the residual ridge.

Changes in tissue contour involved the entire labial plate, with a consequent loss in height and thickness of the alveolar process. Clinically, the maximum loss of tissue contour took place during the first month. Subsequent examinations at monthly intervals showed further loss of the alveolar processes, as determined by the use of an indicator gel. This gradual loss seemed to stop at the end of the fifth month. Subsequent monthly visits until the end of one year showed little or no change in tissue contour (Fig. 4). Relines were made after the construction of the labial flange and at monthly intervals until the end of the fifth month.

Tracings of different sections of one cast showed that greater contour changes took place in the tissues away from the abutment teeth, i.e., at the center of the denture base.

Tracings from the cast of the subject who required extractions of 3 maxillary incisors and whose ridges were well formed showed fewer contour changes than

occurred in the other 2 subjects. These latter subjects had 3 and 4 teeth removed, respectively, and they had ridge formations that were less well formed.

The average tissue loss in a vertical plane and the average loss in a horizontal plane of the 3 subjects at the end of 1, 5, and 8 months and at the end of 1 year are seen in Table I.

During the first month, 68 per cent loss in height and 70 per cent loss in labial thickness occurred in subject 1; 63 per cent and 75 per cent, respectively, in subject 2; and 90 per cent and 75 per cent, respectively, in subject 3. Thus it is during this period that maximum tissue contour changes can be expected. The results showed little or no change from the fifth month on to the eighth month and to the end of a year.

TABLE I. AVERAGE LOSS OF HEIGHT AND THICKNESS OF THE RIDGE

LENGTH OF TIME	AVERAGE LOSS	SUBJECT 1	SUBJECT 2	SUBJECT 3
1 month	In height	3.1 mm.	2.25 mm.	2.7 mm.
	In labial thickness	4.0 mm.	2.9 mm.	2.7 mm.
5 months	In height	4.5 mm.	3.5 mm.	3.0 mm.
	In labial thickness	5.55 mm.	3.75 mm.	3.05 mm.
8 months	In height	4.5 mm.	3.5 mm.	3.0 mm.
	In labial thickness	5.6 mm.	3.8 mm.	3.1 mm.
1 year	In height	4.5 mm.	3.5 mm.	3.0 mm.
	In labial thickness	5.55 mm.	3.75 mm.	3.05 mm.

DISCUSSION

The accuracy of the recordings is dependent on the orientation of the casts. The method adopted is based upon the general principles expounded by Krogh-Poulsen and associates,[10] but it differed in that the plaster of Paris *forms* were sectioned instead of the original casts. The results can thus be checked by repeated casting of the plaster forms and subsequent sectioning, graphing, and measuring. The disavantage is that undercuts limit which tissue can be investigated. For example, in the 3 subjects studied the tissue under observation was limited to the labial section and only part of the palatal section.

So that the probable error in the impression, mounting, sectioning, and tracing techniques could be established, the series was repeated three times. The error was calculated from 150 readings made from the tracings on the graph paper, and the standard deviation was 0.15 mm. Based on these results, this method is being used to investigate the rate, amount, and distribution of tissue contour changes in various age, racial, and pathologic groups.

The rate of contour changes reaches peak activity within 3 to 4 weeks after tooth extractions and change thereafter is less marked, though continuous up to

the fourth and fifth months (Fig. 4). The graphs in Fig. 7 show little or no change a year after extractions. The period of great activity during the first month corresponds to the healing phase of the alveolus, as mentioned by Craddock.[1] The following period of lesser activity until the fifth month corresponds to the phase of continuous resorption. The latter phase is one of changes of the internal bony structure which result in external changes in the shape of the ridges.

These observations affect the clinical stages of immediate denture prosthesis. When the socketing method is employed, the period following immediately after tooth extractions is the time when greatest care should be taken. Recall appointments are imperative. Excessively deep socketing and failure to institute corrective procedures at regular appointments during the first 4 weeks after extractions inhibit the healing process in the sockets (alveoli) and cause excessive resorption of the alveolar ridges. These are the main causes of irregular ridge formation (Fig. 8).

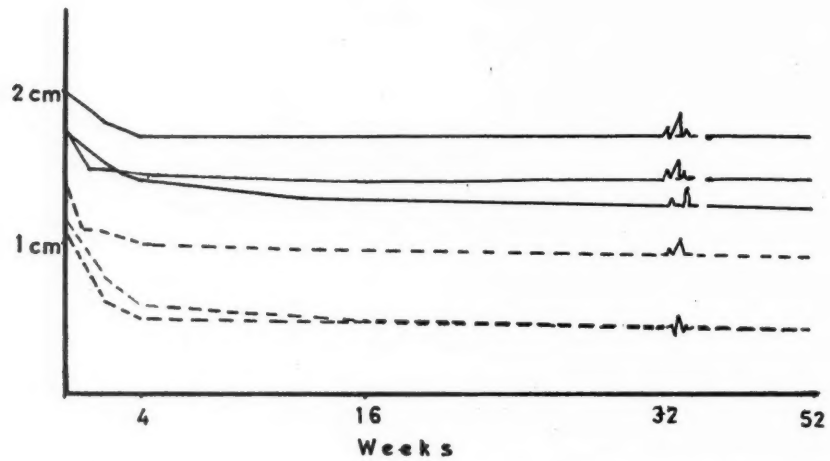


Fig. 7.—The graphs show the rate of change of tissue contour. ————, Change in the vertical plane. - - - - - -, Change in the horizontal plane. Maximum change was observed during the first 4 weeks.

The fact that the alveolar ridges maintained their shape after the fifth month is significant to prosthesis. Little or no contour change took place after this period, and it can be assumed that the bone condition had reached a state of equilibrium. Dentures built after this period, therefore, should rest upon a more stable base in that there would be no noticeable changes in ridge contour.

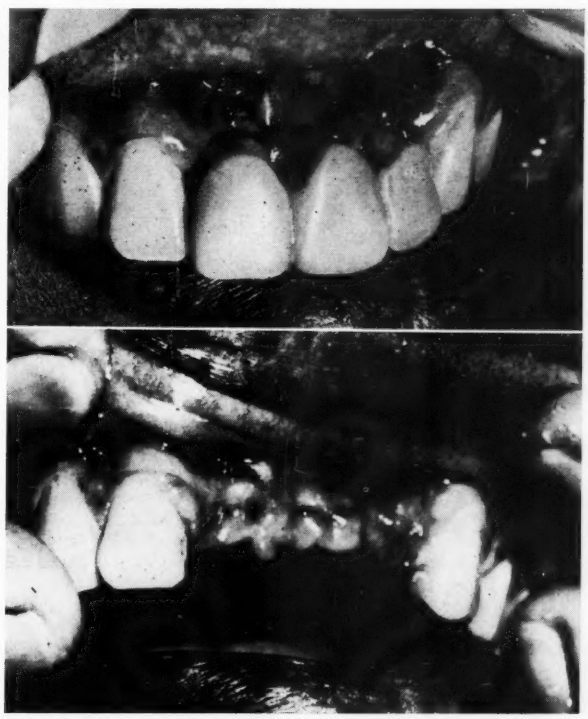
Bone is the most plastic tissue of the body and is never totally stable. It is continually undergoing structural changes that are dependent on the various factors governing bone metabolism and the stress and strains it must absorb. In spite of this variability the recordings of tissue changes show that there is a definite phase of stability of the external shape of bone 5 months following extractions.

Many artificial teeth are socketed to a depth of 3 to 5 mm. Despite care and attention, after 1 month the necks of the teeth separate from the ridges and a labial flange should be constructed. A flange would help in the preservation of

the residual ridges and the denture, while no longer invoking the destructive influences of mechanical stress, would allow wholesome stimulation by functional stress.

Relining of immediate dentures should be planned in keeping with the average pattern of tissue contour changes. After the construction of the labial flange 1 month following extractions, a relining process should be carried out at monthly intervals until the fifth month.

A.



B.

Fig. 8.—Excessive resorption of a residual ridge as the result of failure to institute corrective procedures during the first month following insertion of the immediate denture. *A*, The teeth were socketed excessively deeply. Note the resorption away from the cervical ends of the teeth. *B*, The tissue is badly traumatized.

The results obtained show that greater contour changes can be expected when larger numbers of teeth are extracted. The greater the number of teeth involved the greater is the amount of alveolar bone proper, or of lamina dura, resorbed. Subsequent structural reorganization of bone following the resorption of the lamina dura takes place on a larger scale, and external contour changes also occur on a larger scale. The fact that the subject who had less resorption had ridges that were better formed and broader than those of the other subjects indicates that contour changes are less when the ridge is broad. In such cases the socketing of the teeth should involve sockets less deep, and immediate dentures would need fewer relines.

Unnecessary loss of bone must be avoided during the extraction of teeth. Lisowski[8] states that extensive surgery is detrimental to and contraindicated for immediate denture construction, because alveolar resorption is aggravated proportionately to the extent of the operation. Removal of teeth should be performed with minimum trauma to tissue, and immediate dentures should be designed so as not to disturb the healing process. The dentures should be stimulating rather than traumatogenic.

SUMMARY

A method of recording contour changes of alveolar processes following dental extractions was described. A progressive, over-all picture of contour changes and the rate and the distribution of these changes are discernible by this method. The clinical significance of the results was discussed.

In am indebted to Professor C. H. Graham for his guidance, advice, and encouragement and to Mr. J. A. Jansen for his help. Thanks are also due to Mr. Foo Siang Juan, Mr. Chee Kah Keng, and Mr. S. Yap of the Department Laboratory Staff for technical assistance.

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PROSTHETIC DENTISTRY

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THE APPROACH to the prosthetic problem has been discussed many different ways by many different authors. This article is written for the purpose of pointing out ideas that are not new, but which are practical ideas that have proved successful in the hands of the Indianapolis Dental Research Group.

It is important that study casts be constructed for every patient and mounted on an instrument and that a proper presentation be made to the patient at his second appointment. This procedure has proved to be popular among both edentulous patients and those with a full or partial complement of teeth. In these study casts, the space between the maxillary tuberosity and the retromolar pad, muscle attachments, maxillary tori, mandibular tori, large bony protuberances around isolated teeth, and other factors which might interfere with the success of a prosthetic appliance should be observed. If the patient is to have his teeth removed, pertinent information can be given to the oral surgeon before the first tooth is removed. Through such a study, many patients who had anticipated the removal of all their teeth can be presented with a solution for the retention of their teeth by a full-mouth reconstruction program. It has been observed that the happiest patients are those who can retain teeth they thought were to be removed.

Every effort should be made to present the prosthetic problem to the patient and only when it is necessary, because of periodontal disease or the refusal of the patient to have reconstruction done, should full dentures be constructed. If dentures are to be constructed for the patient, the following procedures are recommended.

IMMEDIATE DENTURES

The most successful immediate dentures are those made when the posterior teeth have been removed first, while the anterior teeth are retained until proper healing of the posterior residual ridge has occurred. The immediate upper denture is inserted along with a claspless lower denture; after a period of 3 to 6 weeks, the lower anterior teeth are extracted and the immediate lower denture is inserted. The claspless lower denture has many advantages. The patient will master the denture; it aids in observation of the occlusal problem; it acts as a support for the upper posterior teeth; and it can be used as a corrected tray for the final impression. Most patients have difficulty mastering the upper and lower immediate dentures when they are inserted at the same appointment.

Hydrocolloid or alginate impressions have been found to be inaccurate for recording soft tissues. Modeling compound trays are built over casts made from an alginate or hydrocolloid impression, leaving the labial surfaces of the anterior teeth exposed. Green stick compound is then used to determine the outline form of the denture. A zinc oxide and eugenol paste is used to record the soft tissues, the crest, and the sides of the ridges. If wide interproximal spaces exist between the teeth, they are filled with inlay wax before the zinc oxide and eugenol paste impression is made. The labial surface and the border of the anterior section are recorded with plaster.

Immediate denture patients are told that frequent relining will be necessary and that they will need a second set of dentures in 6 or 8 months.

MAXILLARY EDENTULOUS IMPRESSIONS

The original impression should be carefully made. An overextended impression in compound is made, and the impression is removed from the tray. The width of the border is reduced and the proper anteroposterior length is determined. Low-fusing green stick compound is used to develop the proper outline form. The original impression is completed in a zinc oxide and eugenol paste. Over the casts of the original impression, processed acrylic resin trays are constructed.

The processed acrylic resin tray is placed in the mouth, and all overextensions are observed. The tray is trimmed to allow for the functional movements of all muscle attachments. Care must be taken to determine the proper anteroposterior length. The patient is instructed to say, "Ah, ah," and the flexure line is noted. This is recorded by using an indelible pencil. After proper preparation of the tray, the detailed outline form is established by using low-fusing green stick compound. The proper distobuccal flange length is determined first. The green stick compound is flowed over the tray in this area. The patient is instructed to contract the buccinator muscle and then blow out. Perpendicular ridges will be developed in the compound which determine the proper length. Low-fusing stick compound is carried across the posterior palatal seal area. The denture is inserted several times. The patient is directed to say, "Ah, ah," and then to "pant." When the detail of the soft palate in function has been recorded, this relining is completed by using a zinc oxide and eugenol paste.

MANDIBULAR EDENTULOUS IMPRESSIONS

As in the upper impression, an overextended impression in modeling compound is made and removed from the stock tray, and a processed acrylic resin tray is constructed.

The tray is placed in the mouth and all overextensions are observed. After proper preparation of the tray the following procedures are carried out:

1. The outline of the retromolar pad is determined by using green stick compound. Care is taken to record the direction of the masseter muscle. The green stick compound is reheated several times to determine this form.

2. Green stick compound is added in the buccal pouch area. The buccinator muscle is pressed inward and pulled forward.

3. Green stick compound is added on the lingual border as far forward as the first bicuspid area. The patient is instructed to extend the tongue and hold the mouth open to the horizontal level of the rest position.

4. Many small holes are bored in the tray over the crest and sides of the alveolar groove. The mucostatic principle is used for recording the crest and sides of the ridge. This is done by drying the mouth completely and inserting the tray filled with zinc oxide and eugenol paste. No pressure is used, and the patient is asked not to swallow until the material has set.

VERTICAL DIMENSION

The recording of a vertical relation and the technique used should be based upon an understanding of the nerve supply to the muscles of mastication, the function of these muscles, and the general adaptation syndrome of the patient. It has been observed that most of the emphasis has been placed upon tactile sense and the free-way space. It is our opinion that these factors have been overemphasized and are of no great importance except as reference points. It is the belief of Kime[1] that the rest position is not a constant, but that it is dependent upon the general adaptation syndrome. From our clinical observation in complete denture work, we believe he is right.

It is our belief that all the methods should be understood, including the Niswonger tactile sense registration, the external measurement using occlusion rims, the Boos Bimeter, and the rest position methods. The variations in the results of these methods often leave us in doubt. A vertical dimension recorded by using the functional movements of swallowing and the opening and closing movement which occurs when the patient repeats the word "sixty-six" is more accurate.

To determine the vertical dimension by this technique, double-thickness baseplates are adapted over the master casts. The baseplates are adapted so their fit approaches that of the finished dentures. Hard baseplate wax is built to the proper height for esthetics on the lower baseplate. Beeswax is added on the upper baseplate so that the vertical dimension is too great.

The patient is instructed to repeat "sixty-six" several times. The patient must move the jaw in a hinge movement. Then he is asked to swallow and rest. By using the rest position recorded as a reference point, it is possible to observe just when the mandible approaches the correct vertical position.

This record is mounted on an articulator, and the teeth are set up and checked in the mouth. At this time the vertical dimension is rechecked by using phonetic tests, such as "fifty-five," "thirty-three," "sixty-six," and the word "chum." If, at this time, the patient has difficulty swallowing or if the phonetic tests are awkward for him, then a new vertical relationship is recorded. The final selection of a vertical dimension is one which in our judgment will meet all the requirements of esthetics, phonetics, and functional anatomy of the individual patient.

ARTICULATORS AND ARRANGEMENT OF TEETH FOR COMPLETE DENTURES

From the observations we have made, we believe that the anatomic positions and physiology of the muscles and the position of Stensen's duct determine the position of artificial teeth in complete dentures. The occlusal plane should be on a

horizontal plane that will allow the tongue to work without any restrictions. The buccal surfaces of the upper posterior teeth should be placed so that the buccinator muscle is retained in its normal functional position and in a normal functional relation to Stensen's duct.

The arrangement of the anterior teeth controls the anatomic form of the modiolus. Therefore, the teeth should be placed anterior to the residual ridge if a great amount of absorption has taken place. The work of Kime[1] and of Mainland[2] on the temporomandibular joint makes us feel that we should use the adaptable type of articulating instrument. Mainland states, "The articulator must perform movements rather like certain mandibular movements, and this entails anatomical problems from which medical as well as dental students can learn much if they glance at some of the dentist's problems—difficulties that have caused different dentists to devise different types of articulators, each strongly advocated by its inventor and each based on a more or less different theory." Therefore, from the anatomic viewpoint it seems that we should use an instrument which will reproduce more than a simple hinge movement.

Cusp teeth should be used. The failures with cusp teeth are caused by poorly balanced occlusion and incorrectly oriented teeth. The first contact of a cusp of a tooth on the working side after it passes through a bolus of food is of great importance, because it is the stimulus for the warning tactile impulse that is carried to the brain to retard the muscle power. The retarding of this muscle power after the first contact of the peaks of cusps will allow the teeth to slide into centric occlusion during swallowing without trauma to the jaw joint or the residual ridge.

SUMMARY

Study casts and roentgenograms should be made for all patients at the first appointment. The prosthetic problem should be presented to the patient so that he might have the choice between full-mouth reconstruction and complete dentures.

Immediate denture impressions should be carefully made. The opinion the patient has of the dentist's ability is dependent upon the quality of retention of the dentures. Individually prepared acrylic resin trays are indicated for the edentulous impression technique.

Determination of vertical dimension requires an understanding of the function of nerves and muscles. The position of the teeth is determined by the functions required of the teeth.

A better understanding of our prosthetic problem will be possible when we as a profession understand more about functional anatomy.

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MORE SUCCESSFUL COMPLETE UPPER DENTURES

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THE COMPLETE UPPER DENTURE has always been considered one of the more consistently successful products of prosthetic dentistry. New techniques for impression making have passed clinical analysis and received practical acceptance. Many advances have been made in obtaining the correct centric relation record. The procedure for insertion of a denture has been given the importance which it justly deserves. Unfortunately, in some instances, construction of a complete upper denture may be troublesome in spite of all the new techniques. Three factors which cause problems in complete upper denture construction will be discussed.

NATURAL LOWER TEETH

The construction of a complete upper denture to function against natural lower teeth is one of the more difficult tasks in prosthetic dentistry. The remaining natural lower teeth, because of use and abuse, may have different degrees of mobility. The line of occlusion is almost always like "hills and valleys." If the teeth of an upper denture were to follow this line of occlusion of the lower natural teeth, any movement in function would unseat the upper denture. Therefore, the lower natural teeth should be shaped by grinding, as much as is permissible according to roentgenographic examination, in order to make the line of occlusion more even. Then the upper teeth can occlude more correctly with and glide more easily over the lower teeth. When the limited grinding of the lower teeth does not produce the required change, however, one or more teeth of the upper denture must be eliminated so that a lower tooth whose occlusal height is higher than its neighbor's cannot strike with an unequal, denture-unseating contact against an upper tooth.

INCISAL AND CONDYLAR GUIDANCE

When only six lower anterior teeth remain or when a free-end denture base removable partial denture has been worn for a long time, special care must be given to the incisal guidance and the condylar guidance in construction of the new complete upper denture. Necessity and habit have taught the patient how to move the mandible forward and upward so that he can chew more easily with the six lower anterior teeth. He has developed an improvised, but normal to him, edge-to-edge functional occlusion.

The upper anterior teeth must be placed so that the lower anterior teeth have enough freedom to move in the new functional protrusive patterns. The upper

anterior teeth must not have any vertical overlap. If, because of esthetics, a horizontal overlap is necessary, there must be enough space between the upper and lower anterior teeth so that the lower teeth can move easily into the protrusive positions that are normal to the patient. Therefore, when a patient is wearing an old removable partial lower denture which has changed position, a new upper denture should be made only if a new removable partial lower denture is made at the same time. The occlusal height of the lower bicuspid teeth must be set at the same height as the adjacent cuspid teeth. In function, this prevents the displacement of the upper denture.

INCORRECT OCCLUSION

Failure of the complete upper denture to function properly results when the teeth of complete upper and lower dentures are ground into an incorrect occlusion. Many dentists have seen the logic and reasoning of grinding the occlusion into the reverse curve; however, the usual success of complete upper denture construction was not always attained by this procedure. Analysis and study led to the conclusion that these failures were common if the teeth were ground into the reverse curve when the vault was flat, the residual ridges were short, and a Class II or Class III throat form was present. The teeth of complete dentures should be ground into the reverse curve of occlusion only when the maxillae are large, the palate has a high, rounded vault, the residual ridges have good length, and the soft palate slopes away from the hard palate at a slight angle (Class I throat form).

SUMMARY

Three factors that make complete upper denture construction difficult have been discussed. If these factors are recognized and techniques established to compensate for them, complete upper denture construction will be more successful.

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DISCUSSION OF "PRESENT-DAY CONCEPTS IN COMPLETE DENTURE SERVICE"

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ROBERTS[1] HAS MADE a comprehensive and historical survey of the past, considered the present, and pointed to the future. Along with the general theme there are interspersed from time to time bits of philosophic spice that could come only from years of experience.

Looking backward, denture prosthesis as we think of prosthesis is only about a century old, although replacements of one type or another of human teeth may be found in the tombs of very ancient peoples. During this past century, many procedures have been developed for the construction of complete and partial dentures. Many opinions have been advocated concerning our problems. Unfortunately for all concerned, opinions are not facts, and many of our present concepts of denture prosthesis are still based upon opinions which can be disputed or refuted, rather than on facts or basic principles which can be interpreted but not refuted. The greater part of our present knowledge and many of our concepts have come from clinical observations and are based upon individual experiences, rather than upon systematic research. If we are to replace opinions with facts and basic principles, we shall require a systematic research program in prosthesis. Since a systematic research program in prosthesis requires time, experience, space, and equipment, few dental schools are doing adequate research in this field. I cannot say what the solution to this problem will be. Most prosthetic division chairmen will probably agree that routine teaching of undergraduate dental students is necessary, teaching staffs are transient, and prosthodontic research is a golden vision which has to be put off to an indefinite future. Perhaps when our present teachers of prosthetics reach retirement age, we may expect them to turn some of their attention to research in place of routine instruction. Then, and then only, we might be able to combine the experience required and the time necessary.

Just a few of the phases of denture construction which certainly need a basis of solid facts will be listed.

IMPRESSIONS

There are two diametrically opposed concepts of impression making: pressure techniques and nonpressure techniques Could it be that both types of techniques

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are of value and the choice depends upon the conditions present? There are many opinions, but no facts. Also, what treatment of the mouth should be instituted prior to making impressions?

OCCLUSAL PLANE

Wilson[2] stated that the occlusal plane should be at right angles to the component of forces of the muscles of mastication. The common concept is that it is placed about half-way between the edentulous ridges and parallel with the ridges. What if the ridge resorption is unequal? Should the occlusal plane vary with the relative relation of the positions of origin and insertion of the muscles of mastication? If so, what if the vertical dimension of occlusion is reduced in older patients? Should the plane position be modified? Is there a relationship between the occlusal plane and various facial types? Here, again, research is required.

EXTERNAL DENTURE FORM

Clinical work on this subject has been done by Fish, Tench, and others, but more concrete data are required concerning the relative importance of ridge relation versus tongue and cheek action and their effect on the stability and masticatory efficiency of the dentures.

FACIAL APPEARANCE

There are many concepts, many trials, many errors, and a general lack of facts and principles regarding facial appearance. Until dentists have a better understanding of and will assume complete responsibility for this phase of denture construction, the standard of facial appearance will be the standard of the laboratory technician who never sees the patient.

VERTICAL DIMENSION

Many theories are plausible, but they do not stand up under the pressure of facts. To date, no facts concerning vertical dimension that can be relied upon are available, neither are there any procedures which do not conclude with dependence upon the judgment of the dentist. Some basic work is being done regarding muscle function, but much more information must be obtained or this phase of denture construction will remain more of an art and less of a science.

CENTRIC RELATION

Anyone who knows exactly where centric relation is for all patients just has not met enough patients. We are just beginning to comprehend the role of muscle action and jaw position. Our concepts are conflicting, and much research will be required in order to place a firm foundation under this very important phase of denture construction. A better understanding of centric and eccentric relations may influence our concepts of posterior tooth form and arrangement.

DENTURE SERVICE

Roberts has pointed out that the edentulous patient is a dental cripple. Dentures do not correct the crippled condition. They merely treat the condition that is present when they are constructed. Hence, as conditions in the mouth change, the dentures must be modified. This means continuing dental service throughout the life of the patient, if damage to the supporting structures is to be minimized. Here, again, much more definite information as to diet, dietary supplements, and geriatric problems in general is required if adequate denture service is to be rendered to the edentulous patient.

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TROUBLE SHOOTING IN COMPLETE DENTURE PROSTHESIS
Part II. Lesions of the Oral Mucosa and Their Correction*

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TRAUMATIC OCCLUSION may be in a horizontal direction when the intercuspation of the teeth is such that it interferes with lateral and protrusive jaw movements. The traumatic occlusion may be in a vertical direction when the teeth do not contact evenly in centric occlusion, i.e., when there is premature contact between the maxillary and mandibular teeth. Lack of uniformity in settling of dentures may be due to faulty occlusal stresses, unequal distribution of the mucosa over the alveolar process, or the presence of spinous processes on the surface of the alveolar bone.

TRAUMATIC LESIONS OF THE MASTICATORY MUCOSA

Lesions on the masticatory mucosa manifest certain features characteristic of their location. They are usually round or irregular in form, but not slitlike as are those on the lining mucosa. The lesions are often small in size (1 to 2 mm.) and their detection is difficult. They represent minute invaginations or small ulcerations of the masticatory mucosa.

The digital examination is of greater value than the visual examination in detection of these minute ulcerations. If on passing the tip of the index finger over the suspicious area the patient's muscles of facial expression quiver, a positive indication of the presence of pain is obtained. This method is even more conclusive than the patient's affirmative reply to the dentist's inquiry about pain. The location of the lesion is completed by marking the denture with indelible pencil and transfering the mark to the mouth. If the coloring matter covers the mucosa in the painful area, the diagnosis is correct. If the coloring matter remains in a small, round concavity in the masticatory mucosa after it is cleansed with moistened cotton, then this is a typical ulceration caused by traumatic occlusion. There are many other typical shapes and forms of ulcerations resulting from various types of traumatic occlusion, but ulcerations on the masticatory mucosa differ clinically from those on the lining mucosa.

Occasionally small areas of severe irritation are found on the lingual slope of the lower ridge when the superficial layer of epithelium seems to be detached from its base. This type of irritation of the masticatory mucosa is caused most frequently by friction of the tissue surface of the lower denture against the mucosa while the denture glides during function (a form of traumatic occlusion). A superficial redness of the mucosa on the buccal side of the lower alveolar process may at

*Part I. Oral Mucosa and Border Extension, J. PROS. DEN. 9:978-987, 1959.

times be observed around the external oblique line. Since this tissue is at the neutral zone, and perhaps slightly beyond it, the redness is caused by overextension of the buccal flange of the lower denture. It is treated the same way as any overextension of a denture border into the lining mucosa.

TRAUMATIC LESIONS OF THE SPECIALIZED MUCOSA OF THE TONGUE

These inflammatory conditions may be caused by tongue biting or by friction of the dorsal surface of the tongue against the occlusal surfaces of the upper teeth. This condition occurs frequently when the upper teeth are set too far off the ridge in a lingual direction. Hypersensitivity of the tongue may also develop as a result of friction of the dorsal surface of the tongue against pronounced artificial rugae of the upper denture. In order to effect correct adjustments of the dentures when patients complain of tongue discomfort, the anatomy and the physiology of this important organ must be known thoroughly.

The mucosa covering the dorsal surface of the tongue is highly specialized; hence the name *specialized mucosa.* The same might be said of the muscles of the tongue. They are probably the most *specialized muscles* in the human body. Consideration of the multiplicity of movements and the great variety of combinations of movements that the tongue effects in speech production, in mastication of food, and in deglutition leads to a realization of how important it is not to restrict tongue movements with dentures.

Posterior teeth used to be set entirely too far off the ridge *buccally.* So extreme was this practice that the labial and buccal surfaces of the teeth considerably restricted the physiologic movements of the buccinator and orbicularis oris muscles. The excess is now in the opposite direction. The teeth in complete denture prosthesis are set too far *lingually* off the ridge, which leads to restriction of tongue movements. The tongue, under these circumstances, may not be able to assume a position of rest in the oral cavity proper because of lack of space for it to stretch and relax. The only direction the tongue can expand or extend is toward the throat, and breathing is made less comfortable.

Artificial teeth are replacements for their natural predecessors in function as well as location. They should maintain the physiologic status quo for the tongue and the buccinator and orbicularis oris muscles. If, however, the tongue is the object of the patient's complaints and it is constricted and restricted by the improper position of the artificial teeth, a change in the position of the teeth is indicated. The lingual cusps of the first upper bicuspids frequently protrude lingually and restrict the lateral borders of the tongue at its anterior third. The lingual cusps of these teeth can often be reduced by means of fine stones and polished thoroughly in order to provide the needed space for the anterior third of the tongue.

The anterior third of the palatal vault of the upper denture may be a great handicap to the dorsal surface (specialized mucosa) of the tongue because (1) the denture base material may be too thick, (2) the artificial rugae may be excessively high, and (3) the relief may be too deep, causing the lingual surface of the denture to protrude excessively into the oral cavity. In any of the three instances the patient

experiences discomfort in phonetics and deglutition because the tongue effects premature contact with the denture-base material. Removing the particular cause of the discomfort effects the cure.

An *insufficient vertical dimension of occlusion* may also lead to frequent and excessive friction of the dorsal surface of the tongue against the denture-base material of the palatal vault and against the occlusal surfaces of the upper teeth. The friction is most pronounced in phonetics and deglutition. In phonetics, the tongue effects many frictional contacts against the upper teeth and denture-base material of the palate to prevent the air from escaping prematurely, as in the pronunciation of *t, d,* and *ch.* In deglutition, the tongue does double duty; it stops the mandible from moving upward and propels the food into the pharynx.

When dentures are worn for many years with an insufficient degree of jaw separation, the papillae in the anterior third and part of the middle third of the tongue may be obliterated. The tongue in this area may appear smooth and shiny.

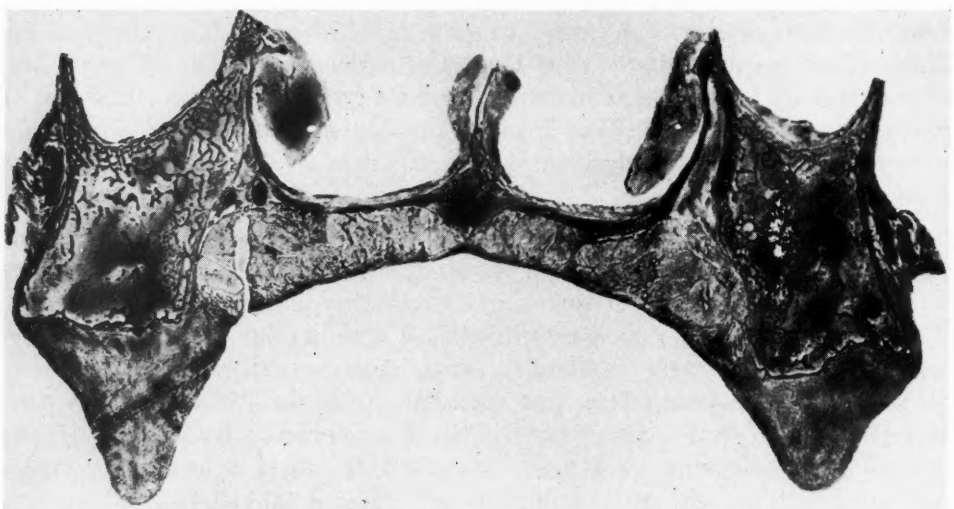

Fig. 1.—A favorable distribution of the mucosa is present on the palatal vault, while excessive amounts of cartilage-like tissue are on the crest of the ridge of right and left maxillary tuberosities. This cartilage-like tissue may have to be reduced surgically to provide room for artificial teeth or denture-base material before denture construction. If it is overlooked, it may have to be reduced during the adjustment period. (From Pendleton, E. C.: The Anatomy of the Maxillae From the Point of View of Full Denture Prosthesis, J.A.D.A. 19:567, 1932.)

TRAUMATIC LESIONS OF THE UNDERSURFACE OF THE MASTICATORY MUCOSA

Under certain circumstances the masticatory mucosa, which is normally attached to the periosteum by means of short connective tissue fibers, becomes detached and loose in some areas. This condition may be caused by advanced periodontal disease, such as the chronic exudative type, and by traumatic occlusion of removable partial dentures. This loose masticatory mucosa constitutes a poor basal seat for complete dentures and causes distinct deficiencies in stability. The dentures

glide upon their respective mucosas during mastication and speech; this, to a small degree, is a characteristic feature of all artificial dentures. With loose mucosa, however, damage to the supporting structures is enhanced greatly, because when the denture moves it drags the loose mucosa along. The friction of the undersurface of this mucosa against the rough alveolar ridge causes pain followed by an inflammatory process of the mucosa and resorption of the alveolar bony support.

This situation causes the patient and dentist a great deal of distress. It takes time for the traumatized undersurface of the mucosa to manifest visible signs of inflammation on its outer surface. This makes the detection of the painful area and the diagnosis of its causative factors difficult. Also, the looseness of the masticatory mucosa in its incipient stages is difficult to detect. It is confused frequently with hypertrophied gingival tissue in the initial stages of its formation or with movable cartilage-like tissue observed frequently in the region of the maxillary tuberosity (Fig. 1). These types of movable mucosa are also considered a liability in complete denture service, but, if indicated, can be excised or reduced depending upon the existing conditions.

An entirely different situation is presented with a masticatory mucosa that is detached from the periosteum. The sites most often involved in this pathologic process are the lingual slope of the lower ridge in the molar region and the region of the six lower anterior teeth. Since the pain is caused by friction of the undersurface of the mucosa against the bone, the ideal treatment would be to effect a reattachment of the mucosa to the periosteum. Since this is not possible at the present time, however, the treatment must be in the nature of a compromise.

For the anterior segment, judicious relief with No. 21 gauge tin foil during the construction of the dentures frequently proves effective. Relief of the same area with burs and stones is much less effective, but nevertheless useful. The following procedure is suggested: Secure a plaster impression of the anterior segment of the final lower cast, pour a metal die into this impression, and then make a counter die for it. Swage a piece of No. 21 gauge tin foil of the proper size and cement it in position on the cast.

Treatment of this kind is not effective for mucosa that is detached from the periosteum on the lingual slope of the lower ridge in the molar region. Efforts must be directed to obtain the highest type of balanced occlusion. Nonanatomic or semianatomic tooth forms with narrow buccolingual diameters are used when the detached mucosa extends over large areas of the alveolar ridges. The goal is to reduce the tendency of the lower denture to glide or skid upon its supporting structures during function. The occlusal surfaces of the teeth are polished highly, and the tissue surface of the denture should be smooth, free from rough projections and sharp ridges. The occlusion should not be corrected in the mouth, but a new centric relation record made and the dentures mounted on an adjustable articulator. The occlusion is then perfected to a high state of balance by selective grinding.

SUMMARY

The study of the various sites of the oral mucosa, in relation to its degree of tolerance of or vulnerability to dentures, should emphasize the importance of in-

vestigating carefully any complaint of pain. It should not be concluded too hastily that reduction of the base material is the remedy, but every effort should be exerted to determine the source of the trouble before undertaking corrective measures.

The classification of the oral mucosa according to degree of cornification follows a definite pattern. Listed in order from the highest to the lowest degree of cornification, there are: (1) the masticatory mucosa, (2) the specialized mucosa of the dorsum of the tongue, (3) the mucosa of the cheeks and soft palate, and (4) the mucosa under the tongue. Nature's design of the pattern of keratinization of the oral mucosa for natural dentitions is also suited admirably to the function of artificial dentures, and its application should be learned. A clear concept of the histologic structure and morphologic perculiarities of the oral mucosa and the physiology of the underlying muscle attachments is required to be able to extend denture borders properly during construction and to reduce these borders correctly during adjustments.

Acute and chronic inflammatory conditions of the oral mucosa can be classified on the basis of their respective etiological factors:

1. Neuromuscular traumatic injuries arising from dentures with or without balanced occlusion.
2. Traumatic injuries of the oral mucosa resulting from traumatic occlusion of various kinds.
3. Inflammatory conditions of the oral mucosa resulting from the mere presence and action of the denture as a foreign body.
4. Poor oxidation and ventilation of oral mucosa covered by dentures.
5. Inflammatory conditions of the oral mucosa resulting from inadequate retention of the dentures.
6. Inadequate resistance of the oral mucosa caused by various systemic diseases.
7. Inflammatory conditions of the oral mucosa induced by endocrinologic and nervous disturbances of various kinds.
8. Inflammatory conditions of the oral mucosa caused by accumulation of infectious material on the undersurface of the dentures.
9. Chemicotoxic injuries to the oral mucosa caused by denture-base materials.
10. Poor nutrition and avitaminosis of various kinds.
11. Allergic reactions of the oral mucosa to denture-base materials.

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TREATMENT FOR LOW TOLERANCE TO DENTURES

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LOW TOLERANCE TO DENTURES remains a major problem for denture patients. In the past this difficulty was ascribed to tissue reaction to the denture-base materials; however, with modern techniques and new materials, this is no longer a valid assumption. Abnormality of the oral mucous membranes and soft tissues has been found to be the most frequent cause of the low-tolerance denture syndrome. Atrophic or degenerative mucosal changes are an indication of the state of all mucous membranes of the body and are probably the result of an underlying metabolic deficiency. Soreness, which is the primary symptom associated with all thin, irritative surfaces, is now correctible, in the majority of patients, with crude liver and certain essential vitamin additives in tablet form.

PROJECT DESCRIPTION

A study was made of 350 patients, all with subjective complaints referable to the oral mucous membranes.[1] The chief complaint in approximately 10 per cent of these patients was denture irritation. This latter group of 34 patients is the subject of the following discussion. The symptoms of these patients were described as soreness, rawness, burning, and dryness, primarily of membranes in contact with dentures. Most of the patients, however, also experienced the same symptoms to a lesser degree throughout the oral cavity. The mucosal surfaces most commonly involved were the sides of the tongue, the buccal mucosa, and less frequently the gingival and palatal mucosa. Removal of the dentures usually gave immediate partial relief from discomfort in the tissues which had been in contact with them. All patients were unable to tolerate their dentures during the night. "Indigestion" was a frequent associated complaint. The majority of the patients were in the sixth and seventh decades of life and gave long histories of gastrointestinal distress.

In a previous article,[2] the relationship of achlorhydria to atrophic and irritated mucous membranes was reported. In the present study, 15 patients (or approximately 44 per cent) were found to have a complete lack of hydrochloric acid secretion. This again is probably an indication of an abnormal state of the mucosal surfaces throughout the body. Women with a prolonged history of this difficulty complained also of dryness and irritation of the eyelids (keratoconjunctivitis sicca)

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and similar symptoms in the vagina. Most patients with histories of prolonged irritation, both men and women, showed involvement of the pharynx with the same symptom complex.

To make the study as objective as possible, only patients who were unable to tolerate their dentures were selected to test the therapeutic effectiveness of various medications.

PATHOLOGY

The basic sign of the abnormal oral mucous membrane is inflammation. The majority of the denture patients with low tolerance demonstrated atrophy of the mucous membranes and marked susceptibility to irritation. The mucosa on the buccal surfaces and sides of the tongue appeared abnormally smooth, with a loss of the normal linear markings. The filiform papillae were either atrophic or absent. Only rarely, however, was the tongue typically "bald." The mucous membranes appeared erythematous due to hyperemia and increased transparency secondary to atrophy. In advanced conditions, there was marked vascular injection of the mucous membranes in contact with the dentures. The membranes were painful and superficial ulcerations were present where irritation was greatest, that is, along the lateral margins of the tongue and the gingival or buccal surfaces. Only rarely were other oral lesions, such as angular cheilosis, gingivitis, leukoderma, or leukoplakia, observed.

ETIOLOGY

In view of the extent of the mucosal changes in these patients, dentures could not be accepted as the cause of the local irritation, only as the triggering mechanism. A definite relationship between oral mucosal atrophy and dietary deficiency has long been established. Manson[3] first introduced this concept many years ago in his treatise on sprue. Many deficiency diseases were known long before the isolation of specific vitamins. One of the first, rickets, resulted from the absence of vitamin D in the diet and caused oral manifestations. Later it was found that supplementing the diet with raw liver could reverse the abnormal changes of pernicious anemia, including changes in the oral mucous membranes.

Spies[4] stated, "The body processes are so integrated, so dependent upon an adequate supply of essential chemical substances contained in foods, that an absence or deficiency of any one important factor may impair the efficiency of the whole chain of reactions." This is demonstrated by the many and varied signs and symptoms present in the various vitamin deficiency syndromes. Since the isolation of crystalline vitamin substances, specific therapy has been available for specific syndromes. Very seldom, however, does one see a deficiency syndrome characterized by the absence of one vitamin alone. As a rule, numerous deficiencies in various vitamins and nutritive substances exist simultaneously.

Martin and Koop[5] have emphasized that patients with abnormal atrophic mucous membranes generally present neither a history of a specific deficiency, nor the physical evidence of such a deficiency. They concluded that specific vitamin

therapy is, therefore, not possible. Their findings have been borne out by this study. Only 2 patients in this series demonstrated a specific vitamin deficiency. Both had pernicious anemia. The remainder had a mixed deficiency, a deficiency in absorption of nutritive substances, or some type of metabolic defect as yet unknown (Fig. 1).

Patients with atrophic mucous membranes may be unable to assimilate or retain a sufficient amount of nutritive substances even from carefully directed diets. Possibly they are unable to utilize these substances properly because of a basic metabolic defect. In any event, from this study and from previous studies, it would appear that vitamin therapy (even with all of the vitamins known at present) has not reversed the degenerative mucous membrane changes for all patients. Crude compounds, including yeast and liver extract, combined with vitamin therapy have been much more effective than has specific therapy in correcting abnormal mucous membranes. This would seem to indicate that there must be unidentified fractions in crude liver and yeast which are responsible for improvement in the condition of the mucous membranes; this improvement, in turn, increases the ability of the patients to tolerate their dentures.

TREATMENT

General, as well as local, conditions must be considered in the treatment of the sore mouth. Obviously, dentures must be determined to be properly adapted and allergy or sensitivity to denture material must be excluded. With these factors ruled out, the problem becomes more general and an underlying metabolic deficiency is indicated. This might include abnormal liver function, abnormal assimilation, basic metabolic defect of some type, or deficient intake.

In order to evaluate the problem effectively, a complete history, physical examination, and laboratory work-up were required. The average diet of this group of patients was found to be lacking in vitamins, particularly those of the vitamin B complex, although there were great variations. Since the most satisfactory source of vitamins and nutrients is natural foods, over-all dietary instruction was given. Even an excellent dietary intake, however, did not relieve the symptoms and complaints of all patients with abnormal mucous membranes. Digestive distress, which was extremely prevalent in this group of patients, called for further relief.

The patients with achlorhydria were made much more comfortable by the addition of acid in the form of Normacid. This in itself partially relieved the symptoms of soreness in 20 per cent of the patients. Therefore, it is believed that supplementary acid is of significant therapeutic benefit, since 8 of the patients with achlorhydria voluntarily continued the acid tablets along with subsequent medication.

As previously stated, many vitamin preparations have been used in an effort to relieve the symptoms and improve the texture of degenerative mucous membranes. Rhoads and Miller[6] first demonstrated that the mucous membranes in many patients with oral cancer were improved symptomatically by the administration of dry, granular brewer's yeast by mouth. Martin and Koop[5] found that beneficial mucosal effects with yeast were incontestable in patients with precancerous lesions, oral cancer, and even controls, even though in many patients no specific deficiency could be demonstrated.

Patients in this series were given a high protein diet, but not all were able to follow the regimen. Poor appetite, digestive distress, and denture irritation were chiefly responsible. Therefore, vitamin supplementation in many combinations, including yeast and the marketable protein supplements, was tried. The yeast and

A.

B.

Fig. 1.—Some of the conditions that are benefited by the treatment discussed. *A*, The mucosa shows degenerative changes with extensive fibrosis from years of irritation and inflammation. *B*, Abnormal oral mucous membranes of an atrophic, irritative type have signs of hyperemic and superficial erosions.

protein supplements were often poorly tolerated because of digestive distress and/or complaints of their unpalatability. Occasional improvement was obtained with vitamins B_1, B_6, and B_{12} in various combinations, both orally and parenterally.

Finally, a tablet containing 750 mg. of desiccated granular liver, 5 μg. of vitamin B_{12} (as Ionex-12), 1.5 mg. of riboflavin, and 0.5 mg. of folic acid was prepared.*

*Mucoplex, the Stuart Company, Pasadena, Calif.

Patients were given three to six of these tablets daily, in addition to the dietary program. The 15 patients with achlorhydria were at first advised to discontinue the Normacid tablets, but after a short time 8 voluntarily resumed this medication because of the additional digestive comfort it gave.

C.

D.

Fig. 1.—*C,* A patient with the Plummer-Vinson syndrome has an atrophic, precancerous mucosa with early cancerous changes. *D,* A mucous membrane, with a benign ulceration, that is atrophic and low in tolerance to dentures.

RESULTS

The 34 selected patients with the low-tolerance denture syndrome were observed under treatment as outlined for 3 to 6 months. At the start of treatment, none of these patients was able to tolerate dentures all the time. Two patients had

unilateral burning of the tongue (glossodynia) and showed no response to treatment. Two others were excluded because of their inability to follow the prescribed regimen. The remaining 30 patients, within 2 to 6 weeks from the commencement of treatment, were able to wear their dentures for 24 hours a day in complete comfort. Six patients continued to have intermittent mild soreness and/or dryness of the oral surfaces other than the gingivae, while the remaining 24 were completely relieved of all oral complaints.

CONCLUSION

An apparently successful treatment has been outlined for the patient with low tolerance to dentures. This regimen includes systematic regulation of the diet, with nutritive additions in the form of a tablet of desiccated granular liver containing small quantities of vitamin B_{12}, riboflavin, and folic acid. This preliminary study would seem to substantiate the presence of substances, as yet unidentified, in crude liver which are responsible to a great extent for the relief of subjective oral complaints and for the more objective finding of increased ability to tolerate dentures.

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NUTRITION FOR THE DENTURE PATIENT*

DETROIT DENTAL CLINIC CLUB, COMPLETE DENTURE SECTION**
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PERFECT HEALTH is a prize that has been the goal of mankind throughout all ages. It must be understood that there can be no separation between good bodily health and good dental health. A diseased body often produces a diseased mouth; in turn, a diseased mouth may often lead to a diseased body.

While the great majority of people have a heritage of good health, many destroy this priceless possession by failure to properly care for their bodies. Much of this neglect is due to a lack of knowledge of the best way to care for this complicated and wonderful machine.

The process of "feeding" the body is not simple. Involved are chemical, physical, and even mental reactions, many of which are still a mystery to scientists. Some fundamental facts, however, are now well established and easily understood.

There is no "cure-all," but this article offers sound and simple advice which, if followed, promises the largest possible measure of health which can be obtained through proper dietary measures.

The words "diet" and "nutrition" are often confused. Diet refers to foods eaten. Nutrition refers to the digestion of food elements and the building and repairing of body tissues by these digested food elements, which are distributed throughout the body by the blood.

A good diet is a basic necessity. The tissues cannot live on food that is fundamentally wrong. A person may "starve" his body even though he puts what he considers good food in sufficient quantity into his stomach. There also must be present the proper vitamins and minerals and then the body must be capable of using these materials and foods properly.

The purposes of this article are (1) to *establish* a proper diet, one that will provide the needed fuel and *body building elements* for the human machine, (2) to suggest, when necessary, additional vitamins and minerals, and (3) to emphasize the importance of proper exercise, relaxation, rest, and, when necessary, medical assistance, to be certain the body is functioning in such a manner that these nutritional elements may be utilized to the best advantage in maintaining or restoring health.

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**The members of the Complete Denture Section of the Detroit Dental Clinic Club are Drs. W. St. Clair Anderson, Stephen G. Applegate, Wesley I. Follis, Earl A. Gelhaar, Henry J. Herpel, B. F. Goodman, Joseph J. Jablonski, Charles H. Jamieson, Paul Kowalchuck, P. C. Lowery, A. A. Nelson, Chester Perry, E. M. Ribits, A. J. Richards, Sr., A. J. Richards, Jr., W. S. Stasiw, Victor H. Sears, Russell W. Tench, H. C. Vorys, A. M. Yeager, and Horton D. Kimball, Director, 1958-1960.

NUTRITION FOR THE PATIENT

Unless teeth have been lost as a result of an accident or removed to improve appearance, it is probable that a major reason for their loss and for the fact that one must wear an artificial dental restorative appliance, such as a fixed partial denture, jacket crown, partial or complete denture, was faulty nutrition. This may appear to be a new concept. Dental nutritional research has demonstrated, however, the direct relationship between the present high consumption of refined sugars, sweets, starches, and soft drinks and the production of tooth decay. In other words, as people eat and drink more of these foods, their teeth decay more rapidly. Faulty nutrition also may have been responsible, in part, if the teeth were lost because of periodontal conditions. Adequate diet and proper nutrition are extremely important in the building and maintenance of healthy teeth, gums, and supporting jaw bone.

The subject of nutrition is complex and one about which more is constantly being discovered. Much of what has been written about nutrition provides excellent and educational reading; on the other hand, there has been much written on the subject which is predicated upon half-truths. While it is difficult to disprove some of these half-truths, one is wise to accept the suggestions of recognized nutritional authorities.

Nutritional authorities agree that food substances may be classified into the following components: (1) proteins, (2) carbohydrates, (3) fats, (4) vitamins, and (5) minerals. A detailed discussion of these food groups would merely serve to confuse those who are unfamiliar with the field of nutrition. Therefore, only a short discussion of the food groups and their sources will be presented.

PROTEINS

Proteins are necessary for building, repairing, and maintaining body tissue, as well as supplying energy. Meat, fish, poultry, dairy products, and eggs are the best sources of animal protein, especially when not overcooked. Peas and beans are among the best sources of vegetable proteins. Among the meats, steaks and chops are hard to chew, but liver and sweetbreads are easier to chew. Ground and chopped meats and many kinds of fish are easy to eat. One can get much of the goodness of meats from soups, broths, and gravies.

Milk and cheese are good protein foods. Cream cheese and well-aged cheddar and Swiss style are preferable to the cheese spreads.

Protein is a "must" for denture wearers. The average patient will have more comfortable gums and the dentures will continue to fit longer if the amount of carbohydrates in the diet is reduced and proteins are increased.

CARBOHYDRATES

Carbohydrates include the sugars and starches and are obtained mainly from plants. They are primarily a source of energy. In our American diet, many of the carbohydrates are in refined form, as in sugar, white bread, flour, and refined cereals. These refined carbohydrates are the "empty calories" and contain little or none of the essentials required for building and maintaining a healthy body and mouth.

Most of the carbohydrates, especially the cooked cereals, are among the easiest foods to eat. That is why there is real danger that too much of them will be eaten. They are called the "energy foods," because many of them supply little except energy; but fats and proteins also supply energy! One could eat little or no carbohydrates, as the Eskimos do, and still have plenty of pep and energy.

Refined sugar is a carbohydrate "energy food." Clever advertising has made some people think of sugar as almost a necessity. The fact is that most people use too much refined sugar and they would be better off with little or none at all.

FATS

The primary function of fats is to produce heat and energy. Only secondarily do they build and repair tissue. Chief sources of fats are fat meats, lard, vegetable oils, butter, cream, egg yolk, and nuts. Fats are an essential part of the diet. They contain vitamins and other nutrients but, in general, should be used sparingly.

VITAMINS

These are chemical substances which promote growth and assist in the maintenance of healthy body tissues. There are times when the body may be unable to provide a sufficient amount of the vitamins and, as a dietary essential, they must be obtained from outside sources.

One who eats the proper variety of food is relatively sure of getting the required assortment of vitamins needed. Denture patients, however, frequently are on a deficiency diet and may need additional vitamins.

Vitamin A.—Vitamin A is essential for normal vision. A marked deficiency may produce what is often called "night blindness." It also helps to keep the skin and the linings of the mouth, nose, and inner organs in healthy condition and thus aids in making them more resistant to infection.

Good sources of vitamin A are egg yolks, butter, whole milk, cream, and fish liver oils. The body can also produce vitamin A from yellow, leafy green, and some red vegetables.

Vitamin D.—Vitamin D is essential because it works with minerals (calcium in particular) to form straight, strong bones and sound teeth. It is often spoken of as the "sunshine vitamin," because the rays of the sun change certain substances in the skin into vitamin D.

Foods such as egg yolk, butter, cream, and irradiated whole milk contain vitamin D. Fish liver oils are the richest natural sources known.

It is advisable to supplement the diet with some vitamin D preparation, especially in the winter when it is difficult to be out in the sun. A physician or dentist should be consulted about the prescribed amount.

Vitamin B Complex.—Thiamine, or B_1, riboflavin, or B_2, and niacin are the best known and best understood members of the vitamin B family. Folic acid and vitamin B_{12} are also very important members of the vitamin B group. They are necessary for a healthy state of the blood.

When thiamine (B_1), riboflavin (B_2), and niacin are seriously deficient in the diet, malnutrition or diseases such as beriberi and pellagra occur. Much more

common are the partially deficient or borderline cases, in which may develop burning of the tongue or cracking at the corners of the mouth. In other instances, the nervous person, the individual who tires easily, the chronic grouch, or the person with vague complaints may possibly be showing the effects of foods which provide too little of these important members of the vitamin B complex. Foods deficient in these vitamins are the refined carbohydrates (sugars, starches, and cereals) to which reference has already been made. This should again emphasize the importance of restricting these foods from the diet.

Good natural sources of thiamine, riboflavin, and niacin are the whole grain cereals and whole grain breads. Leafy green vegetables also contain some of the group. Milk is a good source of the vitamin B group, especially riboflavin. Meats are also good sources, and liver is especially rich in vitamin B_{12}, as well as in vitamin A.

Vitamin C.—A profound deficiency of vitamin C causes scurvy. Less marked deficiencies of this vitamin may manifest themselves, however, by a tendency to bruise easily and by tender gums which bleed easily. Many people get too little vitamin C to be in their best state of health. All of the citrus fruits are excellent sources of vitamin C. Other good sources include tomatoes, fresh strawberries, cantaloupe, and raw green foods, such as cabbage, green pepper, and lettuce. Potatoes contain some vitamin C.

MINERALS

Certain minerals are essential nutritional needs. These include calcium, phosphorous, iodine, potassium, sodium, magnesium, and iron. Other "trace minerals" are known to be important to human life. These include copper, cobalt, manganese, and zinc. Of this group, only minute quantities are required in the diet.

APPLICATION

The essential requirements of the daily diet have been described. The problem of how to apply them remains. In other words, how does one go about obtaining in the daily diet the proper amount of all the materials needed for correct nutrition?

One of the simplest and most practical nutritional systems to follow is the "basic seven." This plan was developed by leading nutritionists (Table I). If used daily as the basis of the normal diet, it will insure an adequate amount of every essential nutrient.

In general, the "basic seven" provides an excellent scheme for a daily plan of eating. If, however, there is gall bladder, stomach, or other intestinal trouble, or other organic illness, a physician should be consulted for dietary advice. The following foods are recommended:

Well-cooked cereals: oatmeal, corn meal, and creamed wheat. (These should be eaten only in moderate quantities.)

Stewed fruits: peaches, apples, prunes, and apricots.

Fresh fruits: crushed apples, pears, bananas, tomatoes, avocados, and oranges.

Soups: rice spaghetti, vegetable, and all creamed soups.

Cooked vegetables: peas, potatoes, spinach, carrots, squash, beets, asparagus tips, turnips, rutabaga, and Brussels sprouts.

Uncooked vegetables: finely cut lettuce, parsley, water cress, and cauliflower.

Fish: boiled, broiled, or baked.

Eggs: poached, boiled, or scrambled.

Ground meats: beef, lamb, and liver.

Cheese: cottage, cream, Swiss, and cheddar.

Desserts: custards, ice cream, tapioca, and rice puddings.

Beverages: sweet milk, skimmed milk, buttermilk, malted milk, eggnog, orange juice, beef juice, pineapple juice, tomato juice, all vegetable juices.

If at any time the gums are tender, almost any kind of food can be prepared in such a way that it will need little or no chewing.

The healthy digestive system changes all foods into more liquid substance, so they can be absorbed and used by the body. Making foods liquid before eating relieves the digestive system of part of its work. This is one reason why a weakened patient is temporarily given a liquid diet. For those who go on a liquid diet, there is one word of warning. The human digestive tract needs a certain amount of "bulk" or solid substance. This does not mean that the solid part must be in

TABLE I

BASIC SEVEN FOOD GROUPS	APPROXIMATE DAILY MEASURE	CHIEF NUTRIENTS SUPPLIED
1. Leafy green or yellow vegetables	One or more servings	Vitamin A chiefly; also, B_1, C, calcium, and iron
2. Citrus fruit or juice	One-half cup juice or two whole fruits	Vitamin C
3. Potatoes, other vegetables, and fruits	Two or more servings	Calories, minerals, and vitamins
4. Milk and milk products (fluid, evaporated, and dried milk, cheese, and ice cream)	Children—1 qt. milk Pregnant women—1 qt. milk Other adults—1 pt. milk	Proteins, calcium (this group is the best source), and vitamins A, B_2, and D
5. Meat, poultry, fish, dried peas, beans, and eggs	One or more servings; one daily preferably (at least 4 per week)	Proteins, iron, and vitamins B_1 and B_2
6. Bread, cereals, and flour (natural whole grain, preferably, or enriched)	Two servings	Calories, iron, vitamin B_1, and proteins. (These are vegetable proteins and are not so readily available as in Group 5)
7. Butter or fortified margarine	To satisfy appetite and energy needs	Calories and vitamin A

Although grain, cereal, and vegetable proteins are "incomplete," their availability is greatly increased when consumed with animal proteins. For example, milk on cereal greatly increases the availability of the protein in the cereal.

chunks. The solids may be suspended in a liquid as extremely small particles—so small that they cannot be seen. These small particles, nevertheless, can furnish the necessary bulk. There seems to be a great difference in the amount of bulk needed by individuals.

The above suggestions should be disregarded if they are not in accordance with the physician's orders.

DIGESTION

If it were not for the pleasure of smelling and tasting, all foods might be gulped down without chewing if it were not for one factor—mixing the foods with mouth secretions is part of Nature's scheme of digestion. All foods should be well mixed around in the mouth and tasted. In that sense, even liquids should be "chewed." *None of the nerves of taste are covered by dentures, so one can still taste all of the flavors.* The sensation of taste telegraphs ahead to the rest of the system to get ready for what is on the way. This stimulates the flow of digestive juices in the stomach and other organs even before the food is swallowed.

After the meal is over, there is little one can do about digestion except rest and stay happy while Nature does its work. Tranquility is said to be the best aid to digestion.

WHY DO WE COOK FOODS?

Cooking is a necessity for some of our foods. If eaten in the raw state, they would not be well digested or could even cause indigestion. Cooking softens foods, making them easier to chew. Of the various methods of cooking, roasting or baking is preferable. Fried foods are less readily digested, while, in general, broiled, baked, and boiled foods are more easily digested.

It is wise not to *overcook* anything and to include in the diet a goodly proportion of fresh, unprocessed, and uncooked foods. Meats should be cooked as little as possible and at a low temperature, with the exception of pork, which must be well cooked. Fruits and vegetables should be fresh and properly ripened. Cooking should be done by the waterless method and at a low temperature.

All water used in cooking meats and vegetables should be saved and used in soups and gravies, since this water residue contains valuable vitamins and minerals.

Perishable canned foods, after opening, or frozen foods, after thawing, should not be kept for any length of time but should be cooked and eaten as soon as possible to obtain maximum food value.

FOR THOSE WHO HAVE ALREADY LOST THEIR TEETH

Although the teeth have been lost, it is most important that the tissues and bones which support the denture be kept healthy. What one eats from now on is going to determine, to a large extent, how healthy these tissues will be . A person without natural teeth can be just as well nourished as one with them. In fact, if he follows the few simple suggestions in this article, he will probably be better fed than at any other time in his whole life.

The removal of teeth and the wearing of dentures may force one to alter his eating habits. Therefore, the necessity for change from solid and fibrous to semisolid and softer foods becomes desirable. Fortunately, semisolid or even liquid foods can supply all the essential elements necessary for good nutrition, and as the individual becomes more proficient in the use of his new teeth, he often can change back gradually to solid and even fibrous foods.

It is true that some persons can eat anything and everything with their dentures. However, some have little feeling in their gums and may injure them without knowing it. Sooner or later the gums may shrink if the load is too great, the bone may dissolve away, and the dentures may become loose. So, go easy on the gums! Do not attempt to chew any but the softest foods until the tissues or gums have become sufficiently accustomed to the pressure of dentures.

Bread is difficult to chew with dentures. Melba toast or crisp crackers will be found less difficult. *Avoid sticky foods. Thorough chewing can be more readily accomplished if the food is taken in small portions and masticating is done slowly. Avoid all foods that require vigorous chewing.* Solid foods can be eaten when the mouth is in condition to properly masticate them.

For the denture wearer, the matter of food is more complicated than merely finding things easy to chew. A proper diet should consist of tissue-building foods rich in protein, minerals, and vitamins essential for healing and repair of the dental ridges. It should also include the energy foods and calories required for daily activities.

By proper nutrition, it is often possible to slow down or even prevent the tissue changes under dentures which contribute to tenderness, soreness, and lack of fit.

CONCLUSION

Appearance of natural or artificial teeth is, to a great extent, dependent upon the physical well-being of the individual. Beauty is not only skin deep, but bone deep.

Health depends upon the quantity and quality of food eaten, as well as on the proper chewing of it. The daily exercise of mastication, when muscular forces are properly directed, is a dominant factor in the preservation of facial contours.

The functions of swallowing and massaging the neck are extremely important in improving blood circulation of the head, throat, and sinuses. These exercises reduce excess tissue and create and maintain a healthier appearance about the mouth and throat areas. Healthy tissue is radiant and improves the appearance of either natural or artificial teeth.

Daily exercise and care of neck muscles is important, especially to women denture patients. When the neck muscles are properly toned, the skin is taut and smooth, with less superfluous tissue and fewer wrinkles. Skin dryness can be benefited by nightly massage with a good face cream. Careful cosmetic attention also assists denture esthetics.

In the study of foods, one should note the superiority, in most cases, of natural foods grown in enriched soil, ripened, properly preserved, and prepared for the patient's consumption with a minimum loss of vitamin content. Do not forget the fact

that heat and certain other factors destroy vitamins in foods. However, many denture patients cannot masticate enough food to supply themselves with a sufficient amount of all the vitamins they need. Thus, it is often necessary to supplement the diet with additional vitamins and trace minerals. Certain foods, vitamins, and minerals help build healthy tissues.

This article is concerned with nutrition and general health in relation to dentistry. The information contained in it, when conscientiously applied, will add to dental comfort and general well-being.

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COMPLETE DENTURES AND TRANSOGRAPHICS

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MOST DENTISTS AGREE on the necessity for two basic prerequisites in complete denture construction. These are an excellent adaptation of the denture base to the tissues and an occlusion which is in harmony with the centric and eccentric positions of the patient's mandible. Thus, the denture problem becomes basically that of how to fit the denture to the patient and the teeth to each other. There are two schools of thought on the fit of the denture, with many subdivisions in each. In one school, varying degrees of pressure are advocated to register an impression of the soft tissues. This "pressure technique" has had successes and failures and has given way to the nonpressure principle, known as mucostatics. This latter principle states that lasting stability demands an impression and denture base that are accurate negatives of the ridge tissues in their normal, passive form. In various modifications of this method, some recommend the complete passivity of the borders, others are proponents of border roll, while still others advocate borders which fall short of any muscle or tendinous insertions.

Appleby[1] makes a complete analysis of these two schools of thought and concludes, "It is granted that the tissues under the nonpressure technique denture are displaced during the two or three hours of mastication, but during the remaining hours of the day, they are in their natural rest position and the denture is maintaining one of its important functions, that of tissue adaptation, and the blood supply to the tissue is not encroached upon.

"For these reasons, it is believed that the ideas presented by the nonpressure group are the ideas of choice."

It is questionable whether the tissues *are* displaced during mastication. Page[2] states four hydrostatic principles as reasons why tissue cannot be displaced under a base. These are: (1) Pascal's law—whenever an outside force is exerted upon a confined liquid, that force is dissipated instantly, undiminished, and in all directions throughout the liquid, (2) all tissue, like any liquid, has unity of movement, (3) all tissue is integumentary and is enclosed completely in a strong, nonstretching mucous membrane, and (4) the laws of hydrostatic pressure transmission.

The need to accurately register the tissues at rest has stimulated the development of all types of impression waxes, pastes, Thiokols, modeling compounds, special tray materials, etc. Similar claims are made for all, so that it becomes rather confusing for the dentist to select a material. Assuming that there is reasonable degree of accuracy with most of the materials, the methods of impression

making and the question of what constitutes a good impression again have created confusion. There are, however, some points on which most dentists agree. These are: (1) the tissues should be registered in a dry state by premedication with an antisialogogue and gauze packs, (2) no portion of the tray should be visible through the completed impression, and (3) some method of perfecting a posterior palatal seal is necessary on upper dentures.

The proper outline form of the lower denture has been debated many times, with varying degrees of success reported by various advocates of different techniques. Again, there are some special considerations which are generally agreed upon: (1) the muscle and tendinous attachments should be free from impingement by the denture border, (2) the retromolar pad should be covered when possible, and (3) the tissue over the external oblique ridges should be utilized for support.

ACRYLIC RESIN AS A DENTURE-BASE MATERIAL

No matter what the accuracy of a denture impression, unless its tissue surface can be reproduced without distortion, we have undergone wasted motion. Although countless dentures have been processed in acrylic resin and are worn with a reasonable degree of comfort, the material does undergo severe distortions because of processing and water sorption. Vulcanite was more accurate as a denture-base material.

The distortion of the acrylic resin base is a primary cause of denture failure. Therefore, we should plan the construction of dentures with an accurate base. This is only possible with cast metal. The metal may be chrome-cobalt alloy, gold, aluminum, or some other. If the casting technique is good, the fit of the base will be nearly as accurate as the impression. Cast-metal bases lend themselves to better therapeutics, maxillomandibular registrations, try-ins, etc., and their value far outweighs the slight additional cost of construction. Any attempt to perform these vital steps of denture construction on bases made of baseplate and other nonfitting materials must lead to trouble, extra work in the postinsertion stage, and frustration.

THE THEORY OF TRANSOGRAPHICS

The occlusion is developed and based upon the use of the Transograph and a knowledge of the theory of Transographics. Without a full understanding of the instrument and the theory, any attempt to use the instrument is doomed to failure.

Transographics is based upon four concepts, and a brief review of these will contribute information bearing upon the denture technique itself, although the application is the same with any type of restorative procedure. The concepts are those regarding (1) the hinge axis, (2) the Bennett movement, (3) the cranial plane, and (4) the envelope of motion.

Every body that rotates while bearing upon another surface contains a theoretic center of rotation and is controlled in its movements by that center. So it is with the temporomandibular joint; therefore, it is necessary to transfer the axes of the

joints to an instrument capable of accepting them. Then, the axes will represent the controls over the rotational movements of the mandible. The same situation would exist if the center of rotation of a wheel were duplicated. The wheel would be thrown into centricity or eccentricity depending upon the new location given to the axle and its axis.

The condyles are irregularly shaped bodies which are also asymmetric in size, shape, and relative position to the planes of the head. This asymmetry results in a bodily shift, called the Bennett movement, and is a component of jaw function, primarily of the opening and closing movement. As a component of function, the Bennett movement also must be incorporated into the articulating instrument.

Since we are dealing with casts of the patient's mouth, it is also necessary to orient the upper cast spatially to the hinge axes of the articulator. Thus, the off-sagittal plane movements of the mandible will be duplicated. The incorporation of a cranial plane into the instrument establishes a constant relationship between the entire cranium, the maxillae, and the transverse hinge axes. The cranial plane makes possible the accurate duplication of jaw rotation around the vertical axes (side-to-side rotation) and around the sagittal axes (jaw rocking).

Having recorded the axial control centers and the Bennett movement and incorporated a cranial plane, the articulator must be capable of reproducing the envelope of motion of the mandible. An envelope of motion can be understood by visualizing a ball-and-socket joint where the socket is fixed and the ball has a rod 6 inches long attaching it to the socket. The envelope of motion of such a mechanism is the inside of a hemisphere having a 6-inch radius. The pattern of function is within this hemisphere.

Every jaw has a functional jaw pattern which operates inside the full envelope of motion. Both are controlled by the same axes. The full envelope comprises all movements the jaw *can* make; the functional jaw pattern comprises the normal functional movements the jaw *does* make. The full envelope, for instance, includes bruxomatic lateral excursions which are destructive. The functional jaw pattern comprises only those movements that *avoid* such destructive excursions. An envelope of motion is developed whenever "any curve or surface while moving under some law (such as hinge-axes controls) maintains constant tangency with another curve or surface."[3] Hinge axes in the Transograph provide the control. By attaching the jaw movement guide to the mandible with guide cams set to the patient's functional movement *borders* and by maintaining tangency between the cams and the cranial plane extension of the maxillae (the cam follower), this functional jaw pattern will be duplicated.[4]

Having hypothesized these four concepts, it is necessary to select an instrument capable of accepting and orienting casts mounted according to these concepts. The Transograph is such an instrument. It is routine to fabricate restorations with anatomic teeth which can be transferred to the mouth without deflective occlusal contacts. It is also possible to retransfer casts of completed restorations to another Transograph and duplicate the occlusal relationship of the teeth precisely. Thus, the instrument is self-checking and is an invaluable aid in diagnosis and treatment.[5-11]

THE UPPER IMPRESSION

A preliminary modeling compound impression is made and an artificial stone cast poured. An acrylic resin or double-thickness baseplate* tray is made on the cast. Relief may be provided, although it is necessary only to allow space on the labial and buccal sides of the crest of the ridge.

The purpose of the final impression is to obtain an accurate reproduction of the semidry tissues in normal, passive form. For saliva removal, the patient is given premedication of 150 mg. of either Pro-Banthine or Atropine Sulphate. One is given every hour beginning 3 hours before the office visit, and the fourth given

Fig. 1

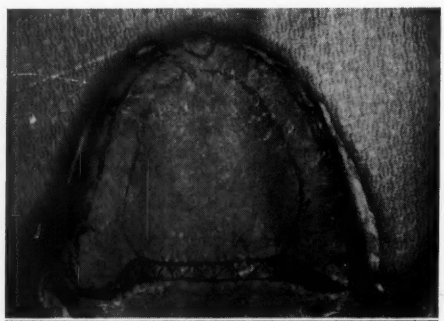


Fig. 2

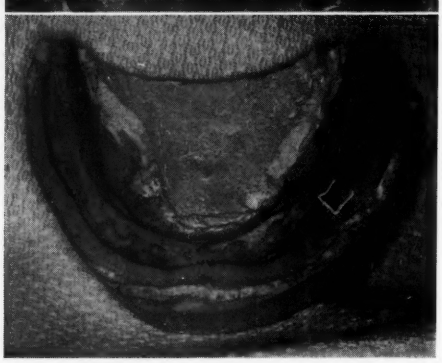


Fig. 1.—The outline of the upper casting is drawn on the cast. The posterior palatal seal area will be finished in acrylic resin. The border of the casting terminates just beyond the crest of the ridge but does not cover the incisive papilla.

Fig. 2.—The outline of the lower casting is drawn on the cast.

if needed. Even small amounts of saliva can appreciably affect the accuracy of the impression. When necessary, gauze packs are placed over the tissues to remove any remaining saliva while the impression material is being mixed.

An impression paste† that has body, but flows readily, is used for the final impression. The tray is filled with the material along the posterior border only. The tray is inserted in the mouth in a posteroanterior direction, so that the

*Ackerman's Tra-Base, Ackerman Dental Mfg. Co., Santa Monica, Calif.

†Ackerman's Paste, Ackerman Dental Mfg. Co., Santa Monica, Calif.

material will flow forward until it escapes under the labial flange. After that, the tray is held with extremely light pressure until the impression paste sets, whereupon the impression is removed and examined for accuracy. The impression is trimmed to remove any sharp edges and the gross excess and is replaced in the mouth and tested for stability and retention. Stability is tested by rocking the impression laterally in both posterior sections. If loosening occurs, it is not stable, and the impression material is removed from the tray and a new impression made. If there is no apparent movement of the impression with this first test, a sharp instrument is placed against one side and a positive pull is used to dislodge the impression. The impression should exhibit considerable resistance to this pulling force in order to be acceptable. The final cast is poured in artificial stone (Fig. 1).

Fig. 3

Fig. 4

Fig. 3.—The lower casting is made of a chrome-cobalt alloy.
Fig. 4.—The posterior palatal seal area of the upper casting is perfected with a zinc oxide and eugenol impression material.

A paste-type impression material is used because it sets to brittle hardness and, thus, can be tested many times for fit without destroying its accuracy. An impression made with a rubbery or semihard material could not be re-examined or tested as easily.[12]

THE LOWER IMPRESSION

A similar procedure is followed for the lower impression. The prepared tray is overfilled and placed in the dry mouth. The impression is trimmed and tested for stability and retention. It is virtually impossible to achieve the same degree of both of these qualities; they are relatively easier to obtain on the upper impression.

A lower impression is never "held" in the mouth in mucostatics. It rests in the mouth without attention. The patient's mouth is open part way and relaxed, with the tongue relaxed on the floor of the mouth until the impression material sets.

The lower cast is poured and the outline of the denture is drawn on it (Fig. 2). Overextension of the borders is carefully avoided. The lower casting (Fig. 3) is made of a chrome-cobalt alloy, with a 1.0 mm. wide finishing line at the borders. The border is the thickness of a silver table knife.

COMPLETING THE UPPER DENTURE BASE

The completed upper casting is returned to the mouth with a lining of impression paste in the posterior palatal seal area (Fig. 4). The impression paste is trimmed, and the casting is replaced in the mouth. An impression tray for an upper edentulous arch is modified by making large finger holes in the bicuspid areas, and plaster of Paris is inserted in the tray. The two index fingers fit through the holes in the stock tray and hold the upper casting firmly against the palate while the reflecting tissues are registered for forming the flanges of the denture (Fig. 5).

Fig. 5

Fig. 6

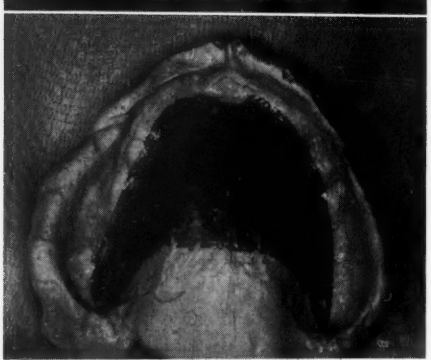


Fig. 7

Fig. 5.—The holes in the impression tray permit the casting to be held in place while the final impression of the borders is made.

Fig. 6.—The final impression is completed in plaster of Paris with the casting in position in the mouth.

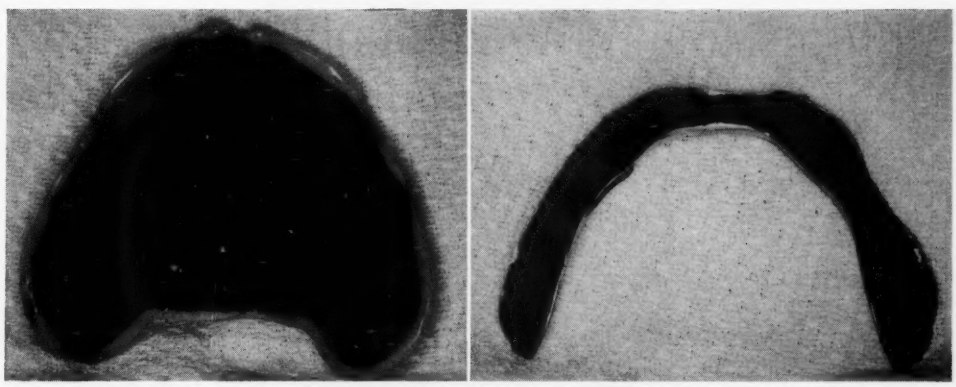
Fig. 7.—The flanges and the posterior palatal seal area are processed in acrylic resin to complete the denture base.

The completed impression is examined for detail (Fig. 6). There should be no plaster under the casting, and the registration of the border tissues at rest should be perfect.

A cast is poured into this completed impression, and a posterior palatal seal is carved into the cast. The flanges and posterior palatal seal area are waxed up and processed in acrylic resin (Fig. 7). The completed base is checked for fit, tested for comfort and stability, and can be worn by the patient before the denture construction is continued.

MOUNTING CASTS

Moldine is placed in the undercuts in the bases, and artificial stone casts are poured into them (Fig. 8). The bases can be removed from and replaced on these casts as desired. The casts are used to mount the bases on the Transograph and are referred to as "mounting casts."



A. *B.*

Fig. 8.—Moldine is used to fill the undercuts, prior to pouring the "mounting" casts. *A*, The maxillary casting. *B*, The mandibular casting.

LOCATING THE TRANSVERSE HINGE AXES

A mandible clamp is used to attach the lower casting to the hinge-bow. The casting is attached firmly to the oral section of the clamp with wax, and the assembly is placed in the mouth with the casting in place on the lower ridge (Fig. 9). Adjustable set-screws on the two vertical arms permit the chin clamp to slide up and grip the lower border of the mandible firmly and prevent movement of the assembly. The crossbar and attached side arms are slid onto the clamp rod and attached firmly with the universal joint connector. This apparatus and procedure create a rigid connection between the lower jaw and the hinge-bow. The only places where free movement can occur are at the styli, which are located opposite the condyles. The styli rotate as the mandible is rotated in pure hinge motion (Fig. 10). By following a systematic procedure of micrometric screw adjustments, the positions of the styli are adjusted until the styli do not arc during these opening and closing movements. When the transverse axial centers are located, the styli

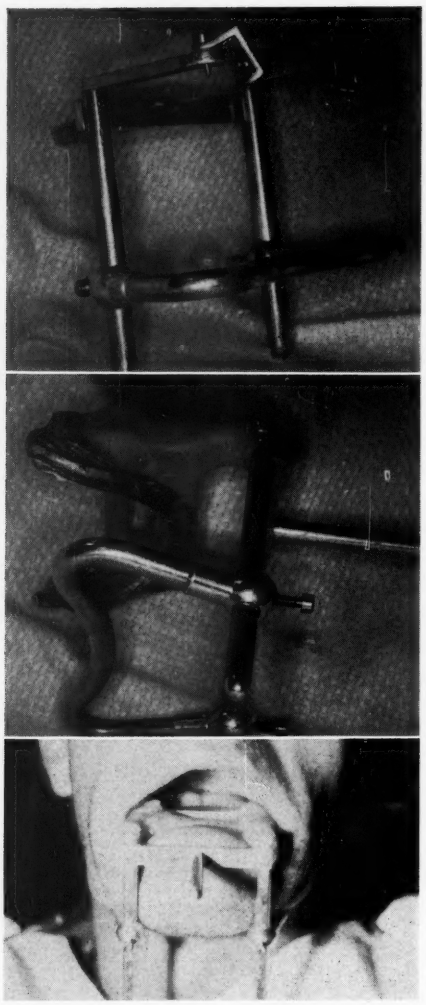


Fig. 9.—*A*, The "mandible clamp" is used to attach the lower casting to the hinge-bow. *B*, The lower casting is attached to the clamp. *C*, The assembly is placed in the mouth. The set screws are loosened on the vertical arms to permit the chin clamp to be adjusted under the mandible.

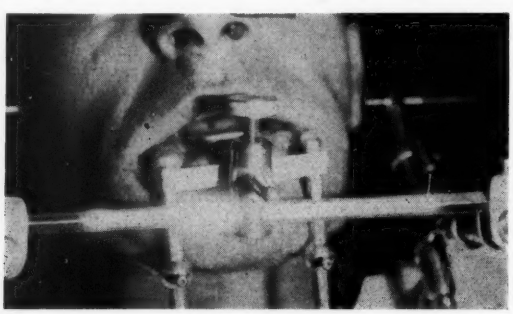
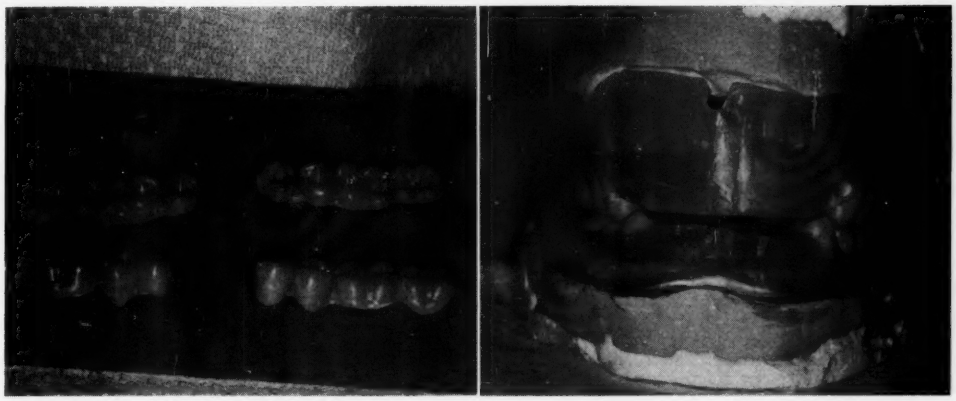


Fig. 10.—The hinge-bow is attached to the mandible clamp. The styli rotate as the jaws open and close.



A. *B.*

Fig. 11.—Prefabricated acrylic resin tooth blocks are used for the initial setup. *A*, The acrylic resin blocks. *B*, The tooth blocks are set in the wax occlusion rims.

are inked and spun against the skin to mark their locations. Subsequently, these marks may be tattooed with pink ink to record them permanently, so they can serve as reference points for the cranial plane transfer and for mountings which may be made at any future time.

The entire assembly is removed from the mouth, and the lower denture base is removed from it. Wax occlusion rims are built up on the upper and lower denture bases, and a wax interocclusal record is made approximately at the desired vertical dimension. The casts are mounted on a plane-line articulator. Prefabricated acrylic resin tooth blocks are set to approximate occlusal contact (Fig. 11). These blocks are used because they can be held securely by the wax and will maintain their positions while wax interocclusal records and other registrations are made. Individual teeth may be used, but, no matter how securely they are waxed in place, they have a tendency to loosen and come out of the wax occlusion rims.

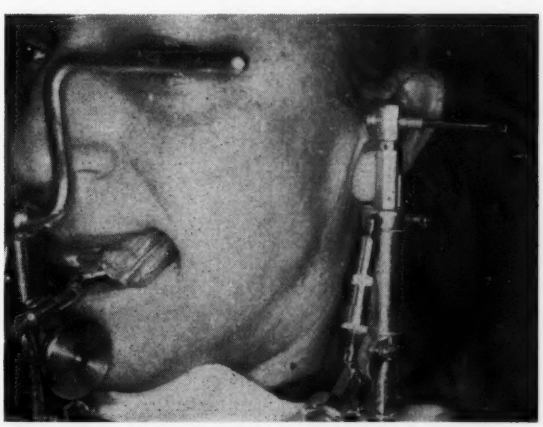


Fig. 12.—The fork and head relator are in position. The styli are set on the tattoo marks.

Fig. 13.—Eight wax interocclusal records of three different thicknesses are used for the mounting and verifying procedures.

Fig. 14

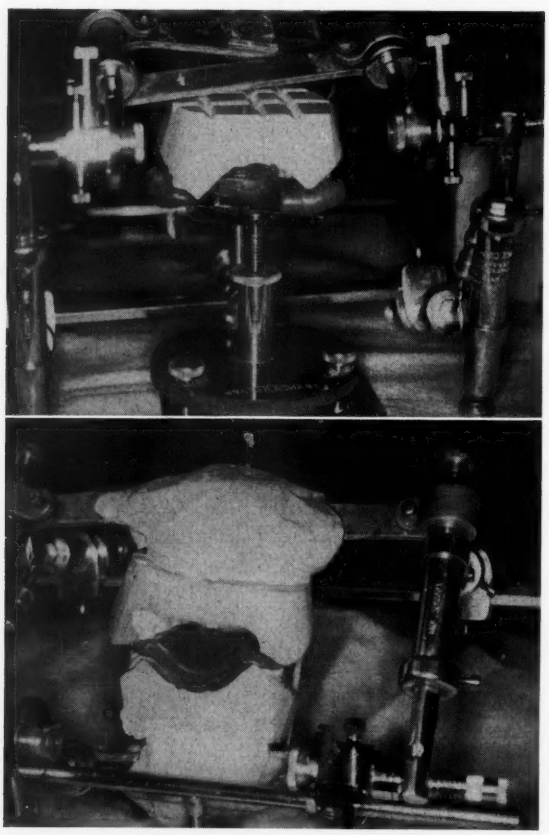


Fig. 15

Fig. 14.—The upper base is placed on its mounting cast and seated in the wax impression. The hinge-bow is converted into an articulator by removing the styli and attaching the slide-slider assembly and apposing arms. Mounting fingers are attached to the apposing arms. Quick-setting stone is used to attach the cast to the mounting fingers. The mounting support prevents any torque.

Fig. 15.—The instrument is inverted, mounting fingers are attached to the base of the side arms, and the lower cast is placed into one of the wax interocclusal records. Quick-setting stone fixes the cast in position.

After the acrylic resin blocks are approximately oriented to each other, the casts are removed from the plane-line articulator and prepared for the mounting procedure. For this purpose it is necessary to correctly relate the upper cast to the hinge axes (Fig. 12). The bite fork of the hinge-bow is held with a wax matrix between the clenched jaws. The head relator is attached with its horizontal bars at the level of the pupils of the eyes, and the hinge-bow is attached to the stem of the bite fork with the universal joint connector. The styli of the hinge-bow are adjusted by the micrometric screws so that their tips are on the tattoo marks and the entire assembly is locked together securely and removed. This procedure establishes the relationship between the cranium, the maxillae, and the transverse hinge axes. With this relationship fixed, the vertical dimension may be changed as necessary without affecting mouth function.

A series of eight wax interocclusal records, varying in thickness from two to eight folds of wax, is made (Fig. 13). The patient is guided into the hinge position for making these records. At least three of the eight records, each at a different jaw separation, must check on the articulator before the mounting can be accepted as correct.

VERIFYING THE MOUNTING AND INTEROCCLUSAL RECORDS

The styli are removed from the side arms of the hinge-bow. The slide-slider assemblies (see Fig. 16), with axles that replace the styli, are placed on the instrument. Two apposing arms with mounting fingers complete the conversion of the hinge-bow into an articulator. A cam follower stem is placed on the most anterior mounting finger (Fig. 14). The apposing arms rest on the top of the head-relator horizontal bars.

Since any plane can be located by only three points in space, the cam follower and the transverse hinge axes, which have been recorded by the instrument, complete the necessary triangle for orienting the cranial plane.

Although the concept of the cranial plane may be difficult to understand,[13] the clinical application of it and the use of the instrument are simple.

An adjustable mounting support is placed under the fork and brought into light contact with the undersurface of the wax (Fig. 14). The upper cast and occlusion rim are seated into the imprints made by the acrylic resin tooth blocks, and the upper cast is attached to the mounting fingers with quick-setting artificial stone. One of the eight occlusal records is selected, the instrument is inverted and supported in a level position, and the lower cast is mounted (Fig. 15).

The slide-slider assembly of the Transograph (Fig. 16) consists of a slide plate which moves freely inside its slider housing when three screws are loosened. These screws have pointed tips that fit into V-shaped socket bearings in the slide plates and are threaded through bosses fixed to the slider sleeve or housing. One screw centers the plate, another locks it, and the third limits its movement. All three screws are tight when the upper and lower casts are mounted. By loosening the screws, or removing them, the different interocclusal records can be placed in position on the occlusion rims, and movement (if any) can be observed between the slide plates and slider housings as the centering screw is tightened or loosened

(Fig. 17). A deviation of as little as 0.02 mm. is readily discernible to the eye. Schweitzer[13] states, "The arrangement of the condylar slide plate and slider is the most accurate method of checking interocclusal records that I have ever seen on any articulator."

When three more occlusal records of varying thicknesses produce no discernible movement, the mounting is considered to be accurate (Fig. 18). The fact that these records are of different thicknesses and the instrument accepts them with no

Fig. 16

Fig. 17

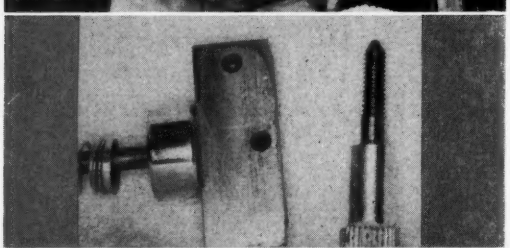


Fig. 18

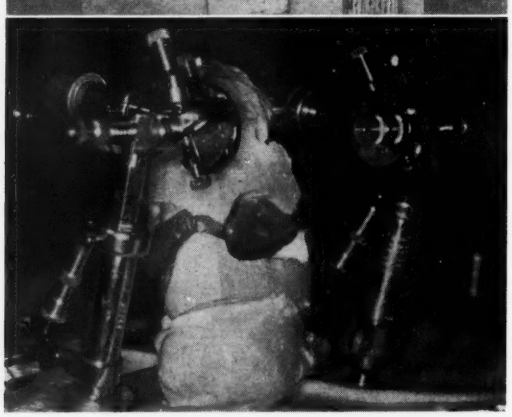


Fig. 16.—The slide-slider assembly. The large screw is the centering screw, the smaller screw at the top is the locking screw, and the one underneath is the limiting screw.

Fig. 17.—The slide plate and centering screw are removed. The tapered end of the screw fits into a tapered seat in the plate.

Fig. 18.—A thick interocclusal record is used to check the mounting. There has been no movement of the slide plate in its housing when the screws are loosened.

movement of the slide-slider assembly is proof that the transverse axes controlling the opening and closing movements of the patient's mandible have been recorded upon the instrument. Otherwise, there would be deviations as the different thicknesses of the wax records were tested.

COMPLETING THE DENTURES

The tooth set-up is completed using anatomic teeth (Fig. 19). All interfering tooth contacts are adjusted by deepening fossae or reshaping marginal ridges. The tips of cusps are never reduced.

When an esthetic appearance is attained, the dentures are processed. The upper denture is flasked with its acrylic resin base intact. After the wax is boiled out of the flask, the resin is burned away from the stone cast and metal casting and the flanges are processed along with the other resin parts of the denture. The lower denture is processed in the usual manner. The *mounting* casts for the two bases are left undisturbed on the instrument.

Fig. 19.—The completed setup and wax-up. The posterior teeth are anatomic teeth.

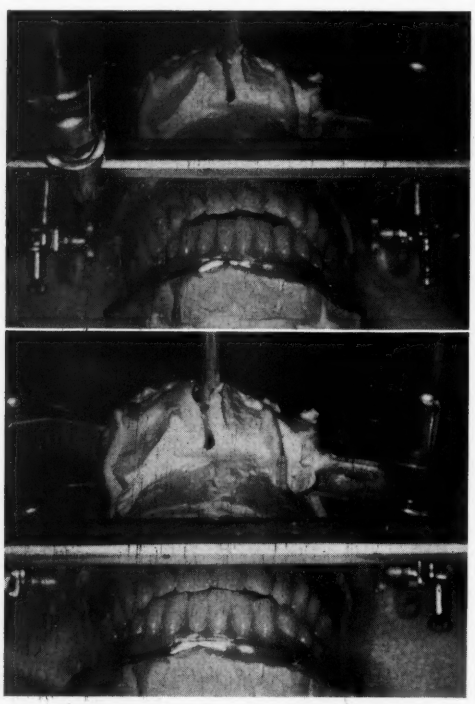
The processed dentures are polished and returned to the mounting casts on the articulator for the correction of processing errors. These errors are eliminated by grinding the teeth to approximately the proper occlusion, using dental tape markings as a guide (Fig. 20). After the markings on the teeth *appear* to be equal, thin strips of cellophane are drawn between the opposing teeth (one cusp at a time). When the cellophane draws through the closed teeth with equal tension throughout, prematurities may be considered to be eliminated, provided that there are no contacts on cusp inclines. Such contacts must be reshaped until all cusp tips contact only in the depths of the fossae.

Any interferences that exist as the cusps glide past each other at the flattest chewing angle of which the patient is capable must be removed. The chewing angle has been found to average about 55 degrees from the cranial plane.[13] A jaw movement guide is attached to the instrument, and the cams are adjusted to this 55-degree angle. The locking and centering screws on one side are loosened to permit that side to function as the working side, while the opposite side becomes

the balancing side. The cam follower stem is moved up and down in continuous contact with the cam on the working side. Any *functional* interferences as the teeth glide past each other will force the cam follower stem off the cam. These interferences can be detected with dental tape and relieved. The same procedure is followed for the other sides (Fig. 21).

Dental tape will mark many places that are "stops," just as marks are made where cusps stop in simple hinge closure. Functional interferences exist *only* on inclines. On the working side, interferences on the lower teeth will be on the buccal inclines of both the buccal cusps and the lingual cusps. Interferences on the upper teeth will be on the lingual inclines of both the buccal cusps and the lingual cusps. On the *nonworking* side, interferences on the lower teeth will be on the lingual inclines of the buccal cusps, while interferences on the upper teeth will be on the buccal inclines of the lingual cusps. "Stops" should never be ground when perfecting the occlusion for function.

A.



B.

Fig. 20.—The processed dentures are returned to the mounting casts. *A*, The processing error. *B*, The error in hinge closure has been corrected by selective grinding.

Any attempt to lower the cams to permit tooth contacts at a lesser angle than the the flattest angle of function will destroy the envelope of motion. The cam follower would be forced to leave the cam, thus losing the tangency necessary for the functional jaw pattern.

FALLACY OF OCCLUSAL BALANCE

According to the theories of Transographics, balancing contacts are outside of the functional range and have no part in function. Further, in attempting to achieve occlusal balance, contact between the molars in simple closure is not achieved, and premature traumatic loads on the bicuspids must result. Such occlusion pro-

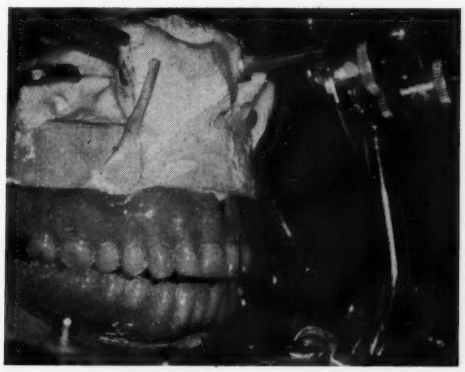


Fig. 21.—The cams (top right) have been raised to 55 degrees and the interferences are removed until the cam follower stays on the cam as the former is moved up and down.

duces trauma and resorption of the ridges and will lead to a skidding of the bases on the supporting tissues. As the bases loosen, the patient's mandible is forced into a convenient protrusive position in order to make occlusal contacts during chewing.

Research has shown that the teeth are only in fleeting contact during chewing[14] because of the bulk, moduli, and viscosities of foods. If this is so, the teeth cannot compress food to such a degree as to attain and maintain tooth contact.[15] Stuart and Stallard[16] said, "Each chewing stroke should be unhelped or unhindered by tooth guidance. No cuspids, no incisors and no cusps should collide with, or rub, or touch opponents . . . ." Kurth,[17] Craddock,[18] and Jankelson, Hoffman, and Hendron[14] have shown that occlusal balance does not exist. Transographics has proved by mathematics that occlusal balance is impossible.[15]

FALLACY OF CONDYLE PATHS

It is contended in Transographics that the condyle paths do not control jaw movement but, instead, that the joints act as adaptable and movable fulcrums for precision. The presence or absence of obstacles at the occlusal surfaces, modified by the muscles and working condyle restrictions, determines the condyle paths. It is the nonworking condyle that scribes the condyle path as the jaw moves laterally in nonfunctional movement. Since the nonworking condyle is rotating and translating at the same time in three dimensions, it cannot be a controlling mechanism but must be a universal joint.

TEMPORARY JAW PROTRUSION

Jaw changes often occur in reverse with dentures constructed by using hinge-axis procedures. The changes take place sometimes in a matter of hours and are either unilateral or bilateral. Unless the causes of temporary jaw protrusion are understood, the dentures made by these procedures may still fail. The procedures are not completed when the dentures are inserted. The mountings are maintained on the instrument for several days, and new hinge interocclusal records are made and checked against the original mounting. Remounts may be necessary, and sometimes it is necessary to remove the teeth from one of the bases, usually the lower, and reset, reprocess, and regrind the occlusion.

Absence of subjective symptoms alone does not eliminate the necessity for follow-up on the patient. Many patients, especially those who have been edentulous for many years, adapt extremely well to almost intolerable mouth conditions.

With careful procedures, almost no sore spots appear on the soft tissues. Occasionally, abrasions appear at the border of the lower denture, at the posterior palatal seal area, or at places around the border of the upper denture. These sore spots are usually due to border overextensions, which should be shortened. No amount of trimming, however, will eliminate ridge soreness. Such soreness can be treated only through a careful analysis and understanding of the occlusion.

The use of the Transograph and a knowledge of its theory enable us to check our work and analyze our errors. The same dentures can be mounted on a dozen different instruments and the identical occlusion will be present on each articulator. Thus, it is possible to study a patient by means of "after" casts and determine whether the teeth are articulated properly. We no longer have to rely on the reactions of patients, many of whom have poor proprioceptive perception or, at the other extreme, are too acutely imaginative in their own diagnoses.

SUMMARY

1. A complete denture technique which included, in detail, the correlation of impression making and the arrangement of the teeth has been described. The concepts of mucostatics and Transographics were described from the theoretic and practical aspects.

2. The four principles of Transographics were discussed, and the use of the Transograph was described.

3. The use of cast-metal bases was advocated to improve the accuracy of the fit of the denture base.

4. Mounting and the verification of jaw relation procedures were outlined.

5. The fallacies of occlusal balance and condyle path influence were discussed.

6. The cause and correction of temporary jaw protrusion were described.

CONCLUSIONS

The principle of mucostatics and the theory of Transographics, if applied with understanding and care, provide the solution to complete denture problems.

The principles of Transographics are applicable also to any phase of dentistry in which the occlusion and the articulation of teeth are factors. The concepts must be applied properly and understood, however, if successful results are to be achieved routinely.

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JAW FUNCTION

Part III. Condylar Placement and Condylar Retrusion*

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IN DENTAL LITERATURE frequent allusion is made to the phenomenon known as forced condylar retrusion into the recess of the mandibular fossa. Many authors[1-9] support the view that posterior displacement of the condyle and mandible is a clinical fact. In addition, much has been written regarding temporomandibular erosions caused by the loss of teeth. Attention is directed to erosion of the tympanic plate of the temporal bone, perforation of the meniscus, pressure atrophy of the condyle and fossa, and perforation of the fossal roof with subsequent involvement of the cranial dura.[10-15] Various pain symptoms generally associated with pathologic disturbances of the temporomandibular articulation are discussed. Some of these are Costen's[16] syndrome, tenderness and radiating pain over the site of the joint, clicking and subluxation, crepitus, tinnitus, vertigo, glossodynia, occlusion of the external auditory meatus, and loss of auditory acuity.[17-20] The inference is drawn that loss of molar support or a total loss of teeth, accompanied by a decreased vertical dimension, is responsible for these erosions by virtue of concomitant strong muscular pulls which force the condyles into posterior and/or superior traumatic positions.

An equally persistent assertion is that the normal functional position of the condyle is against the posterior wall of the mandibular fossa. McLean[21] and Lucia[22] state that normal condylar position during function is in the most superior and posterior part of the fossa. If this were true, which it is not, the theory of posterior displacement of the condyles would be automatically untenable. In like manner, if the advocates of forced condylar retrusion are correct, all restorative procedures for such patients should deal with a forward repositioning of the condyles. This would move them firmly against the articular slope, which anatomists and others generally concede to be the correct pivotal contact during normal function.

In general, anatomy texts indicate the anterior slope of the mandibular fossa as the primary contact area of the condyle during function. Gray's[23] *Anatomy* regards the posterior region of the fossa as nonarticular, often lodging a portion of the parotid gland. Sicher[24] points out that condylar function is limited to the confines of the anterior fossa, the mandibular cavity. This view is shared by others,[25-27] while Page[28] has made the dry and pithy comment, "If freshman anatomy is correct, a condyle rests against the anterior slope of the mandibular fossa." Vaughan[29]

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*Part I. Hinge Rotation, J. PROS. DEN. 9:600-606, 1959; Part. II. Hinge Axis, Hinge Axes, J. PROS. DEN. 9:936-940, 1959.

**Assistant Professor, Department of Prosthetics.

found no evidence of tympanic erosion caused by condylar retrusion in a series of over 60 cadaver dissections. The primary articulating facets were always on the anterior aspect, and the mandibular fossae, when deep, were reshaped with wearing facets only on their anterior walls. He concluded that, contrary to the popular belief of posterior condylar displacement, its natural repositioning is forward and up.

Shapiro and Truex[30] found no evidence of tympanic erosion, no perforations of the fossal roof, and no perforated menisci in a series of more than 100 specimens. In addition, they pointed out that occlusion of the external auditory meatus is anatomically impossible. Batson[31] supports the contention that a closed vertical dimension cannot occlude the meatus. Connors[32] found that loss of teeth had no thinning effect on the meniscus; quite to the contrary, a zone of the medial aspect of that structure became definitely hypertrophied. He believes inflammatory processes and congenital defects are probably responsible for erosions and perforations. Gillis[33] observed that with loss of molar support, the condyle, instead of being driven into the recess of the fossa, is pulled down and away from it. This is a sound mechanical observation of what happens to the temporomandibular articulation when the occlusal resistance factor is shifted forward to the anterior teeth. Higley[34] feels that references to retrusive erosions of the joint are speculative and that erosion probably results from congenital defects, while Junemann[35] found no roentgenographic evidence which could cause either occlusion of the meatus or erosion of the joint structures.

Clinical, roentgenographic, and other means of research strongly suggest there is no such thing as condylar retrusion. Conversations with anatomists have strengthened my belief that dental references to posterior condylar displacements are rationalizations which cannot be substantiated by standard anatomic observations and deductions.

MANDIBULAR POWER CLOSURE

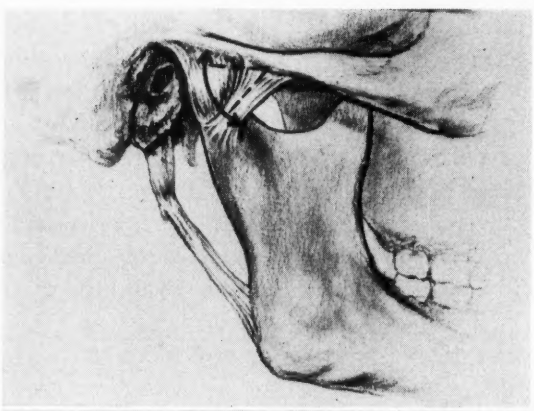
The heart of the matter is approached in the hypothesis of Page[36,37] regarding the temporomandibular ligament as a condylar guide and anchor during power closure (Fig. 1). Through simple observation of the structural arrangement of the masticatory muscles and ligaments and by careful deductive reasoning, he proposed a logical, functional synergy.

At the initiation of the power stroke the rotational axes of the jaw lie at the mandibular angle, corresponding to the insertion of the masseter and internal pterygoid muscles. The condyles are not braced in hinge position but are in free translation forward along the fossal slope. The temporomandibular ligaments are free of tension.

The first muscular action is that of the posterior segment of the temporal muscle which, pulling retrusively against the coronoid process, speeds the working condyle backward up the fossal slope. As the condyle swings back it would be thrust against the posterior wall of the fossa were it not for the restraining effect of the temporomandibular ligament. When this tough, tendinous band is engaged, the condyle pivots about it and arcs forward against the articular slope. The condyle is held firmly in hinge rotational position by the vertical pull of the internal segment

of the masseter muscle (Fig. 2). Thus, two muscular segments operate against the ligament, one retrusively and one vertically. As a result of the leverages, the condyle is rotated up and forward in a normal circular course against the articular eminence. With the condyle anchored in this terminal position, the external segment of the masseter muscle, the internal pterygoid muscle, and the anterior segment of the temporal muscle arc the body of the mandible forward, up, and inward through the bolus to the termination of the chewing stroke. The condyle remains braced solidly against the articular eminence in hinge fulcral position during the entire interval of power closure.

Fig. 1



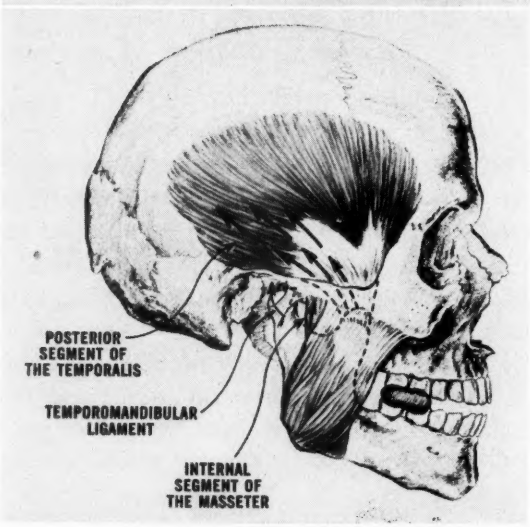


Fig. 2

Fig. 1.—Temporomandibular ligament; condylar guide and anchor in power closure. Note the normal circular course of the condyle as it pivots about the ligament. (From Page, H. L.: The Hinge-bow, D. Digest 58:534-537, 1952.)

Fig. 2.—Working condyle anchored in hinge position during final power closure. Arrows denote the leverage forces directed at the condyle during hinge positioning. The ligament acts as the pivotal mechanism in condylar placement. (From Page, H. L.: Temporomandibular Joint Physiology and Jaw Synergy, D. Digest 60:54-59, 1954.)

It would be tragic if the condyle were braced against the recess of the fossa during function, as the configuration of the chief power muscles demonstrates. Both the external segment of the masseter muscle and the internal pterygoid muscle have insertions behind their origins, which results in a forward pull on the mandible during closure. As Page[37] observed, if the condyle were braced against the posterior fossal wall each power stroke would force it away from its fulcrum, leaving the mandible with no leverage factor in operation. Mechanically this is impossible, because the jaw is a lever and must operate against a fulcrum. Therefore, the articular slope acts in a twofold manner; it prevents mandibular luxation during the chewing stroke and it provides a fulcrum for the leverage system.

TEMPOROMANDIBULAR LIGAMENT

The temporomandibular ligament is of signal importance in the power synergy. It guides the condyle to the articular slope, it controls the hinge rotational segment of the posterior border path, and it prevents condylar retrusion into the recess of the fossa. The anatomic arrangement of the ligament confirms this. From its origin on the zygomatic process, it passes down and back at approximately a 45-degree angle, to insert on the lateral side of the neck of the condyloid process. Any retrusive force applied to the mandible engages the ligament and tenses it, thus making it the structure responsible for the rotational segment of the posterior border path. All constant linear radii involved in hinge closure are the result of maximum tensile length of the temporomandibular ligament.

An exercise in pragmatic anatomy was used to verify the importance of the temporomandibular ligaments in relation to reproducible jaw patterns. A postmortem specimen was prepared for sagittal-plane pantography by stripping away the oral soft structures, leaving the bony framework of the mandible, the teeth, and the temporomandibular articulation intact. This left as the sole operating factors the anatomic structures and mechanical principles controlling all possible border positions. A sagittal-plane pantographic assembly (Fig. 3) was secured rigidly into the bone of the mandible and maxillae. Posterior border path registrations were made by means of retrusive manual pressure against the symphysis, ensuring maximum tension of the ligaments.

Fig. 4, *A* is a tracing made with the temporomandibular ligaments intact. It represents retruded posterior border path movement with rotation confined to condylar line axes and with the entire arc of closure scribed against the taut ligaments. Fig. 4, *B* is a tracing made after bilateral sectioning of the ligaments. There is a clear posterior movement of the field, coincident with sectioning of the ligaments. Visual examination of the joint after sectioning showed the condyles to be resting solidly against the posterior walls of the fossae, while retrusive pressure against the mandible with the ligaments still intact (Fig. 5) demonstrated a potential space in the same region. Indeed, a dissection of any temporomandibular articulation will reveal a comparatively large, nonarticulatory space in the posterior region of the fossa.

The tracings in Fig. 4 indicate two positive facts. First, the ligament controls all hinge-range posterior path movements, which means that the functional power

synergy *is* terminating in extreme border positions. Precise occlusal intercuspation would be impossible were this not true. It does not mean, however, that all functional movements must necessarily follow the posterior border path throughout hinge range. Only the origins and terminals of function lie here. Many functional strokes begin as protrusive ones, but eventually they terminate on the border path. That is why teeth must be articulated to correspond with the hinge-range component of the posterior path. Second, the temporomandibular ligament definitely restrains posterior displacement of the condyle. Accordingly, it is my belief that there is no such anatomic entity as a forced condylar retrusion into the recess of

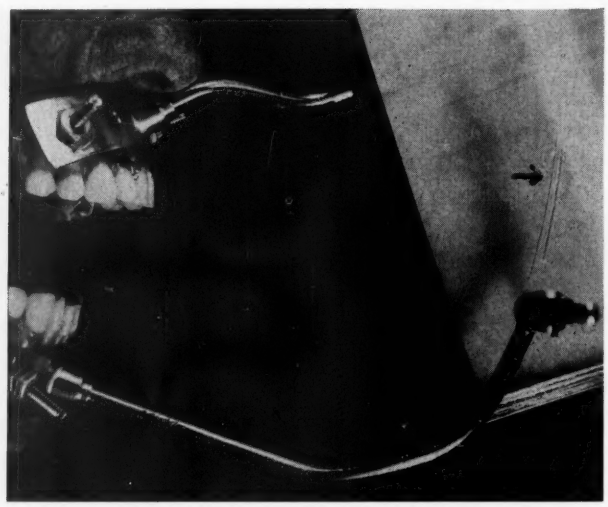


Fig. 3.—The sagittal pantographic assembly in position. The arrow points to the posterior border path registrations made under experimental conditions.

the mandibular fossa. The basic structural anatomy of the joint and the muscular synergy responsible for the power stroke demonstrate this to be true. In addition, I have *never* observed an instance of a posteriorly displaced mandible during clinical use of a line-axis, intracondylar articulator (the Transograph) for various diagnoses and corrections of occlusal discrepancies. Quite to the contrary, all cases display uniformly protrusive relations, and the problem is repositioning the mandible backward to its normal hinge position. Page[38] has discussed the problem of temporary jaw protrusion, while proponents of Transographics have the understanding that all functional pathoses of occlusal relationships are protrusive in nature and require therapeutic measures which restore both normal hinge position and normal tensile length of the temporomandibular ligaments.

SUMMARY

Anatomic exercises relative to border path positions have shown that comparatively inelastic structures are responsible for verifiable and reproducible jaw movements. An acceptable theory of jaw function has shed light on the problem,

particularly since the entire chewing cycle is associated intimately with the mechanics of motion. Since the mandible must move during function, it naturally obeys certain basic mechanical laws. In addition, the underlying anatomic structure of the entire apparatus dictates how the mechanical movement can be implemented. These inherent control factors must be recognized and utilized if teeth are to be articulated successfully.

The problem of so-called mandibular retrusion is an optical illusion and is primarily the result of the basic mechanical inaccuracy of the articulators now used for diagnostic purposes. They are incapable of duplicating a natural, normal hinge

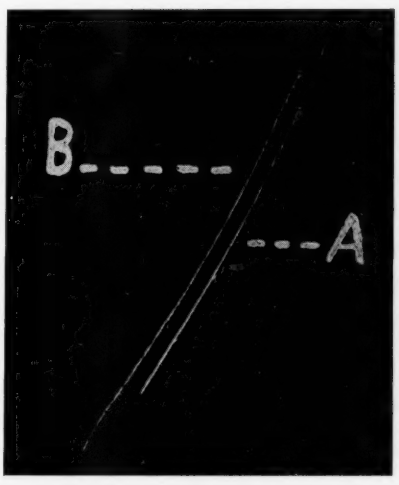


Fig. 4

Fig. 5

Fig. 4.—Etched tracings secured from a prepared postmortem specimen. *A*, the line traced with the temporomandibular ligaments intact. *B*, The line traced after bilateral sectioning of the ligaments. Note that the posterior movement of the mandible caused line *B* to be closer to the joint than line *A*.

Fig. 5.—A dissection of the temporomandibular articulation shows the large nonarticulatory space behind the condyle. The arrow points to the temporomandibular ligament.

occlusion, and casts assembled on them will, in most instances, show the lower occlusal surfaces to be in an apparent retrusion. The reasons for this failure cannot be elaborated now, but the fault lies in the mechanics of the instruments used.

With the functional jaw synergy in action, all power chewing terminates on the rotational segment of the posterior border path, in other words, against the temporomandibular ligament with the condyle anchored in hinge position. This is an anatomic and mechanical necessity, because complicated occlusal surfaces cannot bypass one another without trauma unless they are subject to definite and reproducible controls. The ligaments are of primary concern in the delineation of precise occlusal relationships. They are responsible for constant hinge radii, they guide the condyle to its fulcral position, and they prohibit retrusive condylar invasion into the recess of the mandibular fossa.

The entire theory of forced condylar retrusion is open to serious question, as is the idea of retrusive mandibular occlusal relationships. The answer lies in a conceptual idea of articulation which is being elaborated rapidly. Dentistry will be enriched by this knowledge and the goal of reproducible and precise articulation will be reached.

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MANDIBULAR SHIFTING CAUSED BY IMPROPERLY CONSTRUCTED PROSTHETIC RESTORATIONS

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THE REASONS for the development and existence of prosthetic dentistry as a basic science and as a clinical art are (1) to restore the function of mastication, (2) to restore speech, (3) to provide esthetics, and (4) to give comfort to the patient.[1] Nowhere in dentistry has the ability of the dentist been so taxed as in denture prosthesis. He tries as much as possible to accomplish all of the objectives in his restorations and yet sometimes he has to sacrifice one in favor of another.

Prosthetic restorations are foreign bodies. Clinical records prove, however, that well-planned and well-constructed restorations can function satisfactorily in most mouths. Unfortunately, clinical evidence also shows that some restorations have been associated with certain pathologic conditions and injuries and that the restorations have done harm instead of good. The most serious of these injuries are (1) destruction of the residual ridges, (2) deformation of the mandible, and (3) injury to the temporomandibular joint.[2] Injuries of the first two kinds are clearly visible to the naked eye. The third type has numerous manifestations which usually escape the dentist unless he makes the efforts necessary to observe them. This article deals with deformation of the mandible and the consequent injury to the temporomandibular joint.

CASE REPORT

A female student, 19 years of age, complained of the unsightly appearance of her anterior fixed partial dentures and of the mandible, which had apparently shifted to the right side. Clinical observations showed gross facial asymmetry.

Five years previously an upper anterior fixed partial denture had been constructed. It did not last long because one of the abutment teeth was extracted, presumably as a result of caries. A different dentist constructed another upper fixed partial denture using the upper right first bicuspid and the left lateral incisor as abutment teeth. A few months later, still another dentist extracted the two lower central incisors and constructed a lower fixed partial denture. The two lower lateral incisors were used as abutment teeth. The patient's main complaint after the cementation of the fixed partial denture had been pain in the abutment teeth. The pain disappeared only after she had made frequent visits to her dentist to have the restoration adjusted.

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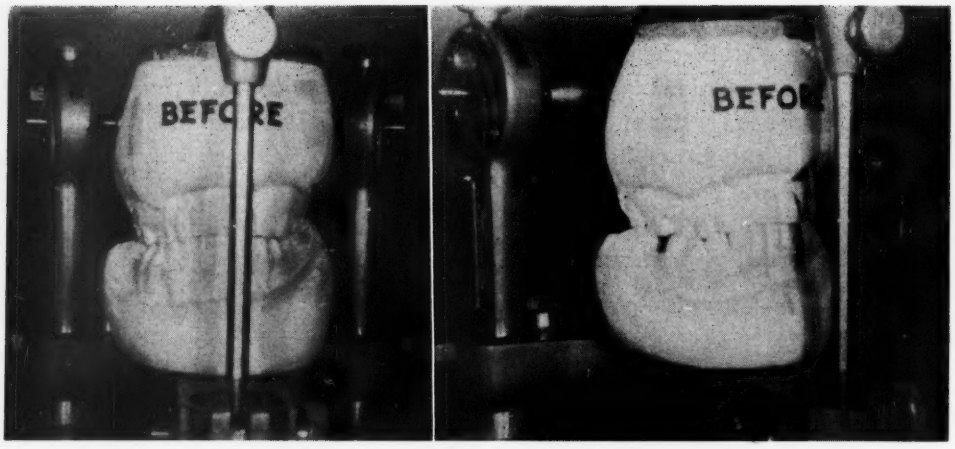
Sometime later the patient noticed that the mandible was shifting to the right side and that a marked change in her facial appearance resulted. At first she tried to correct the deformation by forcibly shifting the mandible to the opposite side. She could masticate food better in the new position, however, since it was troublesome to forcibly shift the mandible to the opposite side and perform a chewing stroke once, only to have the mandible shift to the right again. Later on she noticed that the deformity had become permanent (Fig. 1). This situation had existed for 3 years before corrective treatment was instituted.

EXAMINATION

Records consisted of clinical findings, temporomandibular joint roentgenograms, photographs of the patient, and study casts made before and after treatment

Fig. 1.—The facial asymmetry before treatment was a result of the deviation of the mandible to the right side.

and mounted on a Hanau Model H articulator. Visual and digital examinations revealed an upper anterior fixed partial denture with a space between the pontic and the mucosa. The patient's upper lip sometimes got caught in this space when she smiled broadly. The upper left second bicuspid was carious with pulpal involvement. The lower right second molar inclined lingually about 45 degrees so that the buccal cusps of the upper molar were constantly hitting the inclined buccal surfaces of the lower molar. The lower first permanent molars were missing. The jaw relationship was crossed from the lower right lateral incisor pontic of the fixed partial denture to the second bicuspid (Fig. 2). When the patient moved the jaw to the left side, all of the teeth on that side contacted but all of the molars and bicuspids on the right side were separated.



A. *B.*

Fig. 2.—*A*, The mounted study casts of the deviation of the mandible toward the right side. *B*, The study casts show the anteroposterior cross-bite relationship of the teeth on the right side from the lower right lateral incisor pontic to the second bicuspid. The buccal cusps of the upper right bicuspids occlude with the central grooves of the lower first and second bicuspids.

DIAGNOSIS

A diagnosis of false lateral mandibular deviation was made. The mandible had deviated to the right side, causing the left condyle to assume a forward position in the glenoid fossa. The deviation of the mandible to the right side was caused by the inability of the left condyle to return to its posterior position in the fossa. The condyle was held forward by the fixed partial dentures and the teeth on the right side that were locked in a cross-bite relationship. Examination of the mounted study casts revealed this discrepancy. The buccal cusps of the upper right bicuspids occluded with the central grooves of the lower first and second bicuspids. The patient had to move the jaw slightly downward to disengage the teeth, and then shift the mandible to the left to extricate the locked relationship and thereby correct the deviation. Then the left condyle could move into the glenoid fossa.

There are true lateral mandibular deviations and false lateral mandibular deviations.[3] The position of the mandible with reference to the skull is correct in true lateral mandibular deviations. There is a normal, undisturbed condyle-fossa relationship. The patient can close into centric occlusion and the mandible will be in centric relation. It is very important to refer mandibular deviations to centric relation, because the latter is the key station of all mandibular movements. It is from this position that lateral movements begin and it is in this position again that the movements end. In some mandibular deviations the teeth have a decided "cross-bite" relationship. If a correction is to be made, it should involve a rearrangement of the teeth and not a repositioning of the mandible.

The mandible is in an assumed position with reference to the skull in false lateral deviations. This position may result from a faulty cusp relationship that causes an unnatural locking of the jaws in centric occlusion and shifts the mandible

either laterally or anteroposteriorly, or both. The cause of the deviation is an attempt by the patient to make good contact in centric occlusion. In order to obtain maximum efficiency the mandible must be shifted laterally, thereby causing a false lateral deviation. To correct this situation there must be mandibular repositioning as well as change to a harmonious cusp relationship of the teeth.

TREATMENT

Early removal of the restoration which guided the movements of the mandible would have resulted in the elimination of the shift; however, this patient had progressed to the stage where removal of the fixed partial dentures did not influence mandibular positioning. Changes probably had been produced within the temporomandibular joint which prevented the condyle from assuming its previous position. Therefore, sound teeth had to be extracted to improve function and esthetics.

The two lower lateral incisors, the lower right second molar, the upper right first and second bicuspids, the upper left lateral incisor, and the upper left first

Fig. 3 Fig. 4

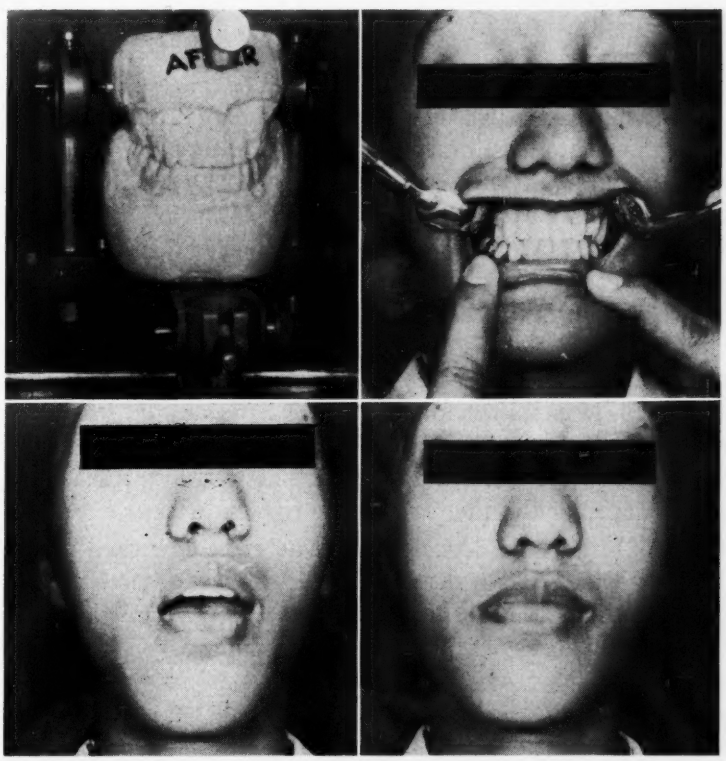


Fig. 5 Fig. 6

Fig. 3.—The study casts show the marked improvement in the relationship of the lower jaw to the upper jaw as compared with the condition seen in Fig. 2.

Fig. 4.—The completed upper and lower partial dentures are in place in the mouth.

Fig. 5.—No deviation occurs when the mouth is opened.

Fig. 6.—The restorations are in place and the jaws are closed in centric occlusion. Note the slight facial asymmetry which is still present.

bicuspid were removed. The upper and lower left lateral incisors were extracted because they were in heavy contact during left lateral movements. The right first and second bicuspids were extracted because they inclined too far lingually.

Upper and lower removable partial dentures were constructed for the patient (Figs. 3, 4, and 5). The guiding inclines of the lower right first molar pontic were increased so that the opposing upper molar would occlude against a steeply inclined plane. The vertical and horizontal overlap of the upper and lower anterior teeth was increased also to prevent the mandible from deviating to the right side. The main objective was to maintain the mandible in this new position. The patient was uncomfortable at first because the mandible and the entire stomatognathic system were being repositioned into a new environment, and pain generally follows such a change.

The mandible cannot be returned immediately to its former position, because that would be too radical a change. The repositioning must be done in stages, until balance and symmetry have been secured. Hence, a slight facial asymmetry still exists (Fig. 6).

DISCUSSION

When the patient moved the jaw to the left side, all of the teeth on that side contacted but the molars and bicuspids were separated on the right side. Since the patient had been forced to masticate on the right side, the right condyle was always the working or pivotal condyle while the left condyle was the balancing or traveling condyle. In lateral excursions of the mandible, the balancing condyle moves downward, forward, and inward in the glenoid fossa and at the same time rotates on the meniscus. The working condyle also rotates on the meniscus, and they both move out of the fossae to an extent determined by the balancing condyle. This lateral movement of the mandible caused the condyles to travel along entirely different paths and wear away both the meniscus and glenoid fossae along different levels. When the mandible was shifted forcibly to the left side, the left condyle became the working condyle and the right condyle became the balancing condyle. Because the angle that the condyle traveled on the left side was not as acute as the one on the right side, a separation of the teeth on the right side was the result.

Treatment of mandibular deviations must never be attempted without carefully made study casts. These casts give an unobstructed view of tooth relations not only from the lateral but also from the distal and lingual aspects. Findings from the casts are correlated with findings made in the patient's mouth.

CONCLUSION

The problem of facial asymmetry has been studied extensively by dentists and artists. Face masks and photographs have always shown a slight facial asymmetry. A symmetrical face is an ideal, one which exists only in the mind's eye and which so far has not been realized. A slight facial asymmetry is not evident, but an abnormal facial asymmetry is easily discernible. The fact that an individual's face has deviated markedly to the left or right immediately leads one to suspect a facial dis-

figurement that is abnormal. Individuals suffering from this deformity usually have the tendency to keep to themselves. When these deformities and asymmetries are caused by improperly constructed prosthetic restorations, it is our duty to correct them as soon as possible. The prevention and treatment of these deformities will sometimes demand the unified action of all branches of dentistry.

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THE USE OF A MUSCLE RELAXANT AS AN AID IN OBTAINING CENTRIC REGISTRATION

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THE REGISTRATION of a clinically valid Gothic arch tracing is at times a difficult and time-consuming procedure. It was proposed that a suitable drug might be of value in expediting the procedure.

REQUIREMENTS OF THE DRUG

The primary requirements for such a drug are: (1) interruption of abnormal reflex excitability, allowing normal skeletal muscle activity without causing concomitant weakness or otherwise altering the normal functioning of the central nervous system; (2) minimal toxicity, with a wide range of safety in dosage; (3) no untoward side effects which might contraindicate its use for the average ambulatory dental patient; and (4) ease of administration.

PROPERTIES OF ROBAXIN

Robaxin was proposed as a suitable drug which possesses these required characteristics. Chemically, Robaxin is methocarbamol, the generic name for 3-(o-methoxyphenoxy)2-hydroxy-propyl carbamate. Robaxin is a white crystalline powder and is supplied in compressed tablets of 0.5 Gm. Pharmacologically, Robaxin exerts prolonged blocking activity on multisynaptic reflexes without significantly affecting monosynaptic reflexes. The drug does not act directly on the contractile mechanism of striated muscle, the motor end plate, or the nerve fibers, but does have a particularly specific action on the internuncial neurons of the spinal cord. Robaxin has a more potent inhibiting action than mephenesin or mephenesin carbamate against convulsions induced by metrozole or electroshock. Clinical studies indicate a wide margin of safety and freedom from side effects following the administration of Robaxin.†

SUBJECTS

Robaxin was tested clinically on edentulous patients of the Complete Denture Clinic, School of Dental and Oral Surgery, Columbia University. The 100 patients studied included 41 men and 59 women, of ages ranging from 15 to 81 years (median age, 57 years).

This investigation was supported by a grant from the A. H. Robins Co., Richmond, Va.
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†Data supplied by the A. H. Robins Co., Richmond, Va.

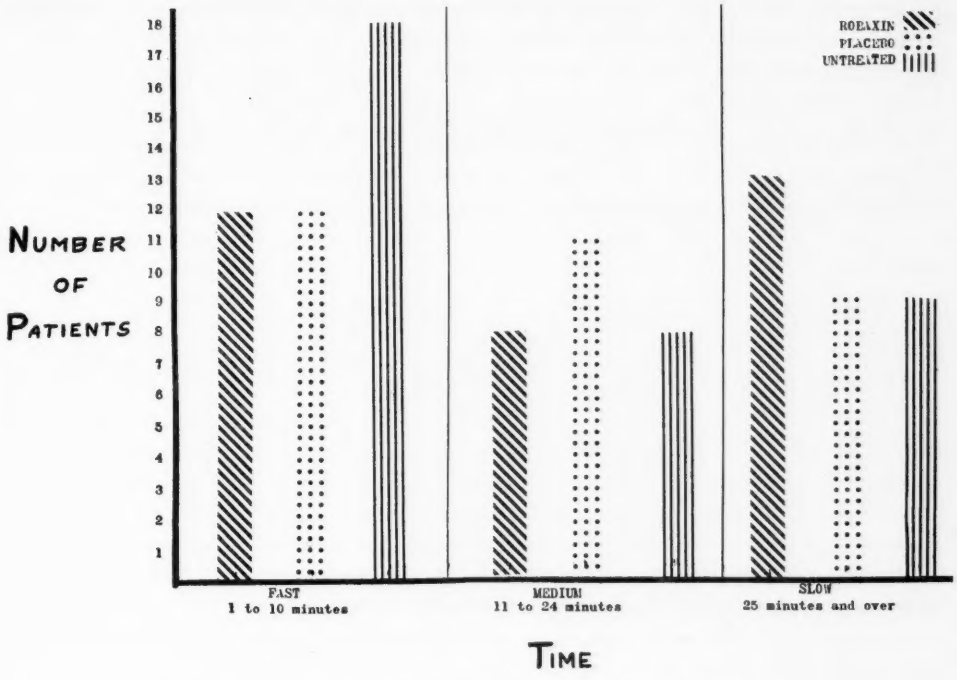

Fig. 1.—Time required to obtain Gothic arch tracings.

CONTROL

The patients were divided into three approximately equal groups: (1) those who received Robaxin, (2) those who received a placebo, and (3) those who received nothing

About 100 index filing cards were numbered consecutively and shuffled thoroughly. The stack of cards was divided into equal thirds. Small envelopes containing Robaxin were stapled to the first third, the placebo to the second third, and empty envelopes to the third group. A key control sheet listing the contents of the envelope attached to each numbered card was made and placed in a sealed envelope to be opened at the end of the study. The cards were rearranged in a box in numerical sequence, and as a patient reached the appropriate stage of construction of dentures, the next card, in order, was used.

PROCEDURE

The Robaxin (1,250 mg. dosage) and the placebo were white tablets of identical appearance. Both were administered orally in one dose. At least 1 hour was allowed for the drug to take effect. The usual procedure of the complete denture clinic was followed to obtain a Gothic arch tracing. This procedure consisted of a single intraoral tracing utilizing a central bearing device (Coble balancer). The tracing pin was mounted on the upper baseplate and the tracing plate on the lower baseplate. Only the usual instructions regarding jaw movements were given the

patients, and special care was taken not to associate the administration of the tablets with the movements. With the correct physiologic rest position and interocclusal distance ascertained, it was further established that the baseplates fitted comfortably in the mouth and did not interfere with one another. The patient was asked to commence the tracing, and the time required to secure a clinically acceptable Gothic arch tracing was recorded to the nearest minute. A clinically acceptable Gothic arch tracing was one that came to a definite apex, with no rounding of the point.

RESULTS

The patients were divided into a fast group (those who required from 1 to 10 minutes to scribe the arch), a medium group (11 to 24 minutes), and a slow group (25 minutes and over) (Fig. 1). The Robaxin, placebo control, and untreated control patients were evenly distributed in the three categories, and no statistically significant pattern could be found. Many factors, including the ability of the dentist, the degree to which the patient comprehends instructions, etc., play a role in the time required to obtain a Gothic arch tracing. No correlation was found between the performance of a patient and whether complete dentures had been worn previously or not. Neither age nor sex seemed to be a factor. No untoward reactions to the drug were observed.

CONCLUSION

This investigation indicates that neither Robaxin nor the placebo helps expedite the making of an acceptable Gothic arch tracing.

The author wishes to acknowledge the valuable assistance of Dr. John W. Fertig, Professor of Biostatistics, Columbia University.

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BALKWILL'S ANGLE FOR COMPLETE DENTURES

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VARIATIONS IN THE SIZE of Balkwill's angle influence the cusp angulation or the sagittal inclination of cuspless posterior teeth in complete dentures. The Balkwill angle is the inclination of Bonwill's triangle to the plane of occlusion, measured in the median plane (Fig. 1). According to Balkwill[1] the size of the angle varies from 22 to 30 degrees, with an average of 26 degrees. This statement was questioned by Köhler,[2] who uses a mean value of 21 to 22 degrees. Hart[3] reports 20 degrees, and Bergström[4] found a mean value of 18 degrees roentgenographically with the extremes at 12 and 24 degrees, but with one instance of 8 degrees.

The object of this article is not to discuss the size of Balkwill's angle but to clarify how variations in it influence the cusp angulation or the inclination of cuspless posterior teeth in complete dentures.

INFLUENCE OF BALKWILL'S ANGLE ON THE CHRISTENSEN ANGLE

The calculation of the cusp angulation for complete dentures is based on the Christensen phenomenon and depends on certain suppositions in the calculation of the Christensen angle.[5] It is necessary, therefore, to examine how the size of Balkwill's angle influences the Christensen angle. The formula for the Christensen angle is: sine $[(\beta \div \varphi) + \gamma] =$ sine $(\beta \div \varphi)$ + p/a sine β (Formula II), where β is the inclination of the condylar guidance, φ is the Balkwill angle, γ is the Christensen angle, p is the length of protrusion, and a is the height in Bonwill's triangle.[5]

The calculation of the Christensen angle in Table I is based on this formula. The angle is calculated for variations in the size of the Balkwill angle as well as in the inclination of the condylar guidance. The protrusion (p) and the height in Bonwill's triangle (a) remained constant.

According to Table I the Christensen angle (γ) increases when the Balkwill angle (φ) decreases, except when the condylar guide inclination (β) equals 15 degrees. The ratio is inverted in this situation. To clarify such an amazing result, the relationship of various Balkwill angles in connection with condylar guide inclinations near 15 degrees was investigated. Table II contains a selected range of condylar guide inclinations from 5 degrees to 30 degrees, but otherwise it is calculated in the same way as Table I.

A certain conformity is maintained regarding the Christensen angle (γ) and the *difference* between the condylar guide inclination and Balkwill's angle ($\beta \div \varphi$)

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(Table II). This conformity is especially marked when the condylar guide inclination (β) is equal to 20 degrees and the Balkwill angle is, respectively, equal to 30 degrees and 10 degrees. The Christensen angle is in both cases, the same size (1.15 degrees). The difference between the condylar guide inclination (20 degrees) and the Balkwill angle (10 degrees and 30 degrees, respectively) is in either instance equal to 10 degrees. The other columns show the same relationship; the Christensen angle *increases* when the difference between the condylar guide inclination and the Balkwill angle *increases*. As a result the cusp angulation, or the inclination of cuspless posterior teeth, varies also because of the relationship between Christensen's angle and the cusp angulation.

The influence of the Balkwill angle on the Christensen angle is so slight that the alteration of the cusp angulation or the tilting (inclination) of cuspless posterior teeth is insignificant. For example, if the condylar guide inclination is equal to 30 degrees and the Balkwill angle is altered from 30 to 10 degrees, the corresponding

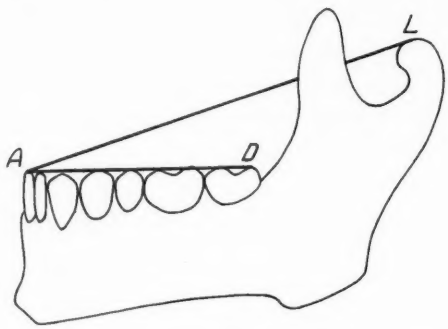

Fig. 1.—The Balkwill angle *(LAD)* is the inclination of Bonwill's triangle to the plane of occlusion.

difference in the size of the Christensen angle is 0.11 degree with 5 mm. of mandibular protrusion (Table II). The influence on the cusp height of the difference mentioned is less than 0.1 mm., and the corresponding influence on the inclination of cuspless posterior teeth is less than 1 degree. This is of no importance. With a condylar guide inclination of 20 degrees, even a theoretic difference does not exist in the size of Christensen's angle when the Balkwill angle is equal to 10 degrees and 30 degrees, respectively. The greatest difference ($\beta = 45$ degrees) influences the cusp height by less than 0.2 mm. and affects the inclination of a cuspless second molar by less than 3 degrees. Therefore, the influence of the Balkwill angle on the cusp angulation and on the inclination of cuspless posterior teeth for complete dentures is not of practical significance.

SIMPLIFIED FORMULA FOR THE CHRISTENSEN ANGLE

Because of the slight influence of the Balkwill angle on the Christensen angle, the formula for the Christensen angle may be simplified. The size of the Balkwill angle is made equal to the inclination of the condylar guidance ($\beta = \varphi$) in the

TABLE I. THE SIZE OF THE CHRISTENSEN ANGLE WHEN THE BALKWILL ANGLE VARIES FROM 30° TO 10° AND THE CONDYLAR GUIDE INCLINATION VARIES FROM 15° TO 45°

φ / β	30°	26°	22°	18°	14°	10°
15°	0.88°	0.87°	0.86°	0.86°	0.86°	0.86°
30°	1.65°	1.66°	1.68°	1.70°	1.73°	1.76°
45°	2.44°	2.50°	2.57°	2.65°	2.76°	2.91°

φ = Balkwill's angle
β = condylar guide inclination
Mandibular protrusion = 5 mm.

TABLE II. THE SIZE OF THE CHRISTENSEN ANGLE WHEN THE BALKWILL ANGLE VARIES FROM 30° TO 10° AND THE CONDYLAR GUIDE INCLINATION VARIES FROM 5° TO 30°

φ / β	30°	26°	22°	18°	14°	10°
5°	0.32°	0.30°	0.30°	0.29°	0.29°	0.28°
10°	0.61°	0.60°	0.59°	0.58°	0.57°	0.57°
15°	0.88°	0.87°	0.86°	0.86°	0.86°	0.86°
20°	1.15°	1.14°	1.13°	1.13°	1.14°	1.15°
25°	1.40°	1.40°	1.40°	1.41°	1.43°	1.45°
30°	1.65°	1.66°	1.68°	1.70°	1.73°	1.76°

φ = Balkwill's angle
β = condylar guide inclination
Mandibular protrusion = 5 mm.

TABLE III. THE SIZE OF THE CHRISTENSEN ANGLE, ACCORDING TO BOTH FORMULA II AND FORMULA VI, WHEN THE INCLINATION OF THE CONDYLAR GUIDANCE VARIES FROM 10° TO 50°

β	10°	20°	30°	40°	50°
γ according to Formula II	0.60°	1.14°	1.66°	2.20°	2.80°
γ according to Formula VI	0.58°	1.13°	1.65°	2.13°	2.54°

β = condylar guide inclination
γ = Christensen's angle
Mandibular protrusion = 5 mm.

formula for the Christensen angle. The simplified formula may be expressed: sine $\gamma = p/a$ sine β (Formula VI), where γ is the Christensen angle, β is the inclination of condylar guidance, p is the length of protrusion, and a is the height in Bonwill's triangle.

The difference between the exact value of the Christensen angle, according to Formula II, and the approximate value, according to Formula VI, is given in Table III. The difference is insignificant.

SUMMARY

The effect of the size of Balkwill's angle on the Christensen angle and on cusp angulation was discussed, and on the basis of the findings a simplified formula for the Christensen angle was suggested.

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THE VALIDITY OF A METHOD USED FOR MEASURING MASTICATORY FORCES

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CONSIDERABLE INTEREST has been shown in the measurement of forces exerted during mastication, with both natural and artificial dentitions. A knowledge of the magnitude, direction, and distribution of these forces is of special value in designing a prosthesis which has high masticatory efficiency and which transfers a minimum load to the supporting tissues. An understanding of these forces is of prime importance when planning the control of loading. Their neglect results in unnecessary discomfort for the denture wearer.

Devices for estimating masticatory forces may be divided into two categories: (1) those which measure the force exerted by the occlusal surfaces of the teeth against the opposing teeth, such as those described by Black,[1] Boos,[2] and Brawley and Sedgwick,[3] and (2) those which measure the force exerted by the denture base against the soft tissues. It is this second type of measurement which is of greatest significance to the prosthodontist.

Because it is difficult to obtain access to the area involved without interfering with the function of the denture, little has been achieved in this field. At the time of this investigation, only one reference describing such a method[4] was found in the literature. Since that method purported to make measurements which were impossible by any other known means, it became an obvious choice for use in clinical tests.

Since that work was carried out, Frechette[5] has published a report in which another method quite similar to that of Stromberg[6] is described. The results of this study will apply to Frechette's method as well.

Before embarking upon clinical tests, a critical examination of the method was made to check its reliability, especially in view of certain theoretic inconsistencies which might invalidate it. This investigation sought to discover weaknesses of the method and, if necessary, to suggest an alternative method.

Stromberg attempted to measure the forces actually exerted by complete dentures against the soft tissue of the mouth during mastication. He used dentures fitted with a movable window on the tissue surface. Masticatory forces caused a depression of the window, which was supported by a spring attached to an electric strain gauge. Associated electric equipment indicated the force required to cause this displacement.

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This evaluation of Stromberg's method was carried out by observing the effects of experimental variations in those factors which seemed most open to criticism: (1) the rigidity of the mount carrying the sensitive measuring device, (2) the thickness of a soft lining used to represent the soft supporting tissues of the mouth, and (3) the magnitude of the load.

In order to avoid the variables which are uncontrollable in clinical tests, the experiments were conducted under controlled laboratory conditions.

THEORETIC ASPECTS OF TESTING METHODS

The diagram in Fig. 1 shows a movable window mounted in the top part of a table (representing a denture). The table is in contact with a soft lining of flexible resin attached to a rigid sheet of Plexiglas.* The resin lining represents the soft tissues of the mouth.

As the load is applied against the table, the flexible lining is compressed, or displaced, and transmits a portion of the load to the window. The window and its supporting beam are displaced downward which, in turn, causes a portion of the load that would be taken by the window (if it were not displaced) to be shifted to the area of the table adjacent to the window. This displacement and load shift will continue until the resistance offered by the spring (or beam) supporting the window is equal to the load on the window. Therefore, the stiffer the spring or beam, the less will be the shifting of the load from the window to the adjacent portions, and vice versa. In the extreme, with a window as rigid as the surrounding part of the denture, there would be no displacement and no shifting of the load. Inasmuch as the load measurement system depends on the movement of the window, there would be no reading for the load determination under the latter circumstances. Therefore, the situation would seem to be somewhat of a compromise between rigidity and instrumentation so that the load on the window may be determined. In order to test the accuracy of this reasoning, several different methods of window attachment with varying degrees of stiffness were used experimentally. Observations were made to determine which of these methods gives the most reliable data.

Another factor to be considered is that the window only follows the displacement of the soft lining. The extreme possibilities are (1) a completely fluid lining which would produce a hydraulic pressure on the window that would be equal at all points regardless of any displacement of the window, and (2) a solid lining which would not become deformed, and consequently would place no load on the window, but would shift the total load to the surrounding table. Therefore, it seemed advisable to compare the results obtained when using linings of varying degrees of displaceability. In order to meet this requirement, tests were performed using linings of different thicknesses.

CONSTRUCTION OF TESTING APPARATUS

The apparatus was made as simple as possible to eliminate uncontrolled variables. A square table top, 5 cm. by 5 cm., was constructed of Plexiglas and sup-

*Colorless sheet methyl methacrylate resin, Rohm & Haas Co., Philadelphia, Pa.

ported by four legs. A hole, 1 cm. by 1 cm., was cut in the center of the table top, and a window was cut from the same material to fit the hole. A small clearance was allowed on each side to permit freedom of movement.

The window was attached to the table top, in turn, by four different mechanisms, each providing a different degree of resistance to displacement. These were (1) a spring cantilever beam, (2) a spring beam supported at both ends, (3) a more rigid window mounting designed to provide greater resistance by supporting

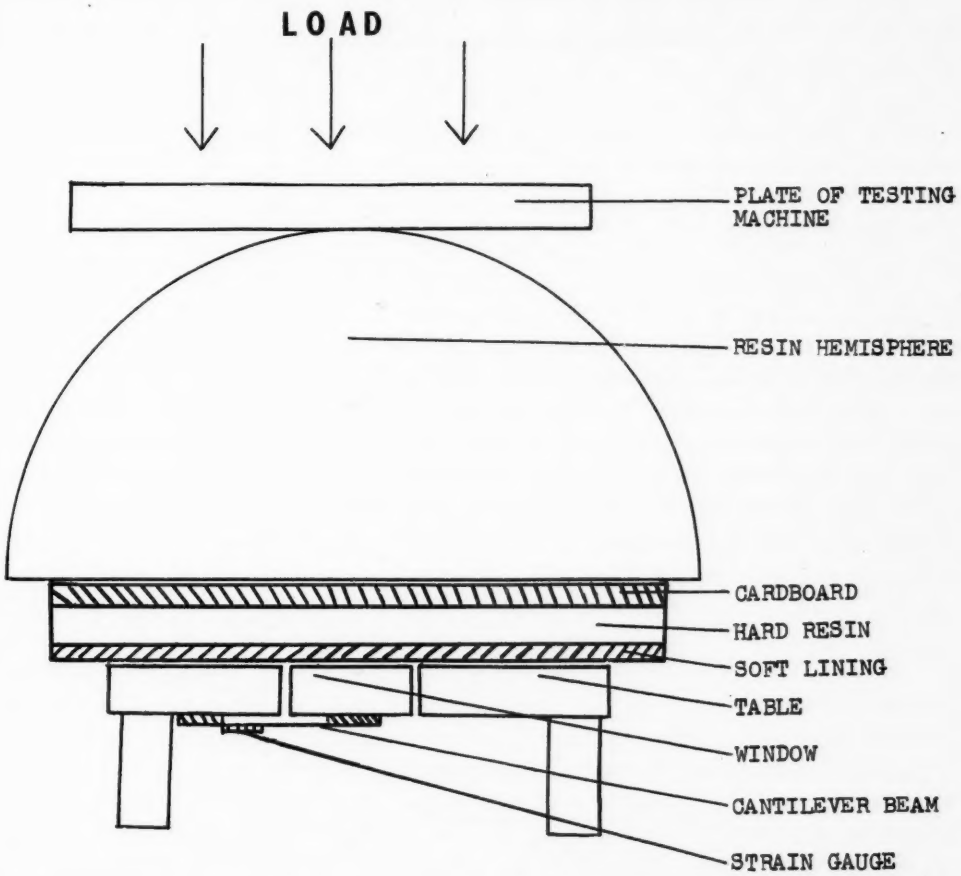

Fig. 1.—The diagram illustrates a table with a window supported by a cantilever beam and the method of loading the table through soft lining, cardboard, and a resin hemisphere.

the window with two vertical gold beams, and (4) a mounting creating even greater window rigidity by replacement of the two gold strips with four Plexiglas posts. A Baldwin SR4 electric resistance strain gauge was attached to the supporting beam in such a manner that pressure applied against the window caused a bending, or stretching, of the beam and a consequent variation of the strain-gauge resistance. This resistance, in turn, was measured by a Wheatstone bridge. The measurement system had been calibrated previously to give the actual load on the window.

CONSTRUCTION OF THE LININGS

The apparatus described so far corresponds closely to the strain-gauge window mounted in a denture. The remaining requirement is a soft lining, simulating gum tissue, through which pressure can be applied to the upper surface of the table and window. King and Lawton[7] indicated that soft body tissues exhibit a rubberlike elasticity when subjected to physical forces. Therefore, a soft rubber or resin lining would have physical properties similar to those of gum tissue.

In order to determine the required degree of softness of the lining, several tests were made on fresh cadavers using a Shore type "A" durometer. A durometer is an instrument used to measure the hardness of relatively soft or elastic material. Gum tissue gave an average hardness reading of 40 to 60 units. Therefore, soft linings made by attaching prefabricated sheets of polymerized Nelson soft denture-lining resin to Plexiglas squares were used.

THE METHOD OF TEST

Direct Load Calibration.—In each test, the strain gauge was first calibrated by directly loading the window with known weights. The amount of strain, as indicated by the strain analyzer in micro-inches per inch, was plotted graphically to show the relationship between the strain and the load on the window.

Loading of the Tables Through Linings.—Loads were applied to the surface of the entire table (25 square cm.) through one or more of the soft linings. If the load were distributed evenly, it would require 25 times as much load to produce a given scale deflection as would be necessary were the window (1 square cm.) to be loaded independently. To ensure even distribution of load over the soft lining, the Plexiglas was covered with a layer of cardboard (a method widely accepted in engineering practice). The load was transmitted at right angles to the surface of the cardboard by a hemispheric piece of acrylic resin (Fig. 1).

A load range from 0 to 50 pounds was used, since this range would include all forces used during mastication with dentures. Loads were applied by placing the table in a Riehle testing machine. Strain readings were made at load intervals of 2 pounds, and the strain-load results were plotted graphically.

Comparison of the results from direct loading of the window with those obtained when loading through a lining showed whether the load was transferred in its entirety through the soft lining to the window or whether it was shifted partially to the adjacent area of the table.

THE TREATMENT OF DATA

The data consisted of strain-load readings obtained during direct loading of the window and strain-load readings obtained during indirect loading of the window. The load was applied through various soft linings over the surface of the entire table.

The data were plotted as illustrated in Fig. 2. The strain readings are shown by the ordinate (scale B), the direct load values by one abscissa (scale C), and the total indirect loads on the table by the other abscissa (scale A). The data obtained

from direct loading were plotted using scales *B* and *C*, whereas the data obtained from indirect loading were plotted using scales *B* and *A*.

For a given total load applied through a soft lining (using scale *A*), the strain on the window can be determined from scale *B*. This same strain reading can be interpreted in terms of actual load on the window from scale *C*. Thus, the portion of the total load applied through the lining that is being borne by the window can

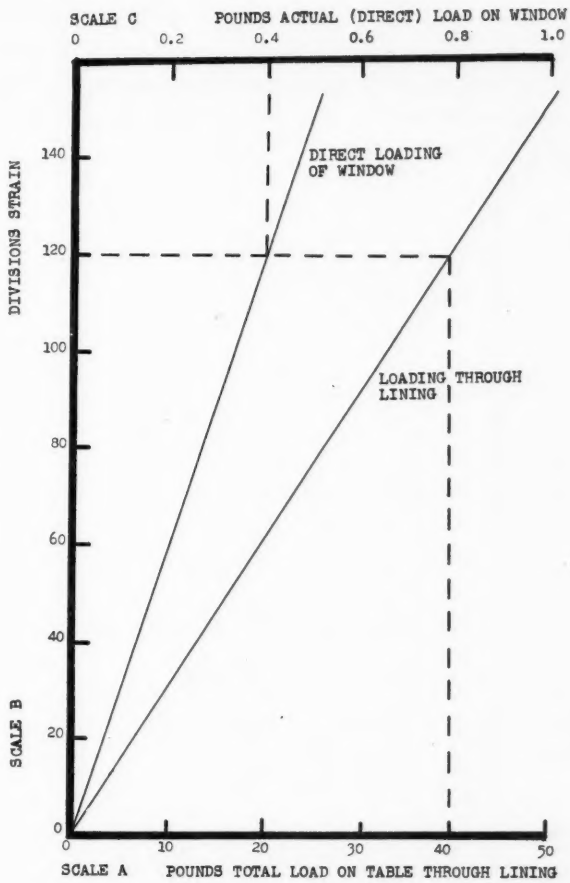

Fig. 2.—Strain readings were obtained during direct loading of the window and during indirect loading of the window through a lining and expressed graphically.

be determined. For example, a total load on the table of 40 pounds (scale *A*) produces a strain reading of 120 divisions (scale *B*) which, in turn, indicates 0.4 pound actual load on the window (scale *C*). Thus when 40 pounds total load is applied to the table through this particular soft lining, only 0.4 pound is actually transmitted to the window. These figures are plotted on another graph (Fig. 3) where the abscissa indicates total load on the table and the ordinate indicates actual load transmitted to the window. Two curves are plotted on this graph. One curve is composed of figures obtained from Fig. 2 showing the ratio of the total load on the

table to the actual load on the window. The other curve shows the theoretic load that would be transmitted to the window were it to bear its fair share of the total load. The window should bear 1/25 of the total load imposed on the table, as calculated by the formula $P_w = \frac{P_t}{A_t}$, where P_w = actual load on the window (pounds), P_t = total load on the table (pounds), and A_t = area of the table (square cm.). This curve is labeled the "theoretic assumed load."

The disparity between curves *1* and *2* shows to what extent the load on the window, as determined by the strain gauge, gives a faulty indication of the load as applied to the table as a whole. For example, a total load on the table of 25 pounds actually produced a load of 0.25 pound on the window, whereas it would have been expected to produce a load of 1.0 pound.

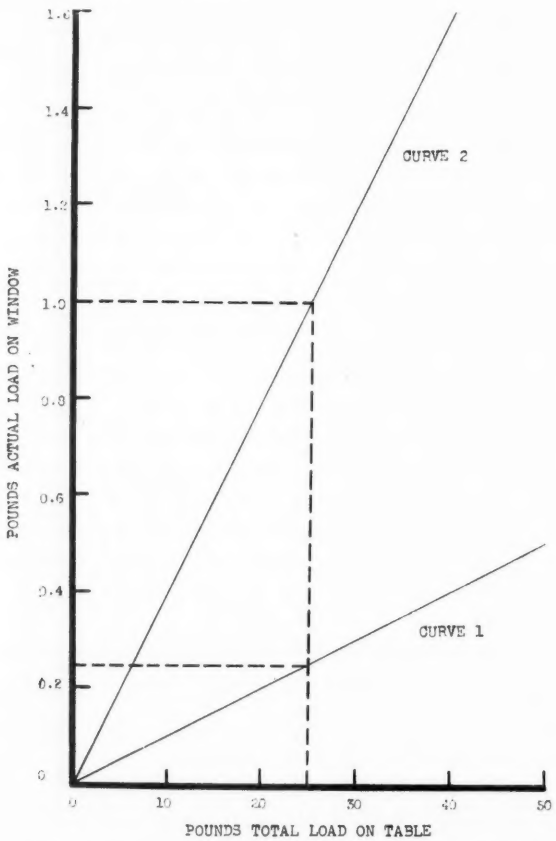

Fig. 3.—Curve *1*, The ratio of the actual load on the window to the total load on the table. Curve *2*, The theoretic expected load on the window.

RESULTS OF TESTS

The results are listed in order of increasing rigidity of the window-mounting apparatus: (1) cantilever beam, (2) simply supported beam, (3) two vertical gold beams in tension, and (4) four Plexiglas posts.

Cantilever Beam.—Fig. 4 shows the results when the cantilever beam is used as a supporting structure for the window. This arrangement was tested through a load range of 0 to 50 pounds, using linings of 0.030 inch, 0.070 inch, and 0.140 inch thickness, respectively. The theoretic assumed load is included also.

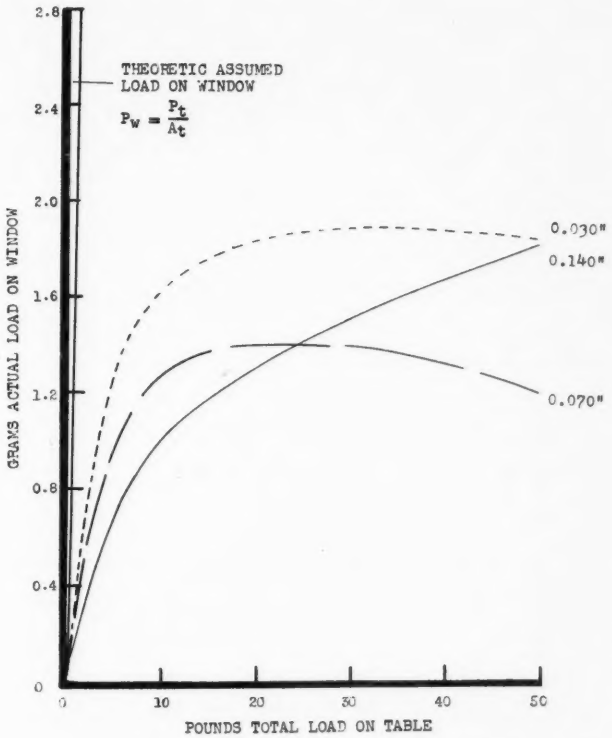

Fig. 4.—The relation of the actual load on the window to the total load on the table when the window mounting was a cantilever beam is shown when linings of 0.140 inch, 0.070 inch, and 0.030 inch were used.

The "assumed load curve" rises close to the ordinate, whereas the curves for the actual loads found on the window rise less steeply and tend to level off at extremely low window loads. Little faith can be put in such a measurement arrangement, because considerable error is present. Even at a low load such as 2.5 pounds total load, which would indicate a theoretic assumed load of 0.1 pound on the window, the comparison of the actual load to the assumed load is not favorable, since less than 1 per cent of the assumed load is indicated as being actually present.

It was suggested previously that the thickest (0.140 inch) lining would transmit the highest load to the window, because it would become deformed and follow the displacement of the window-supporting mechanisms at higher load levels than the others. And, in contrast, the 0.030 inch lining, being the thinnest, would produce inaccuracies at lower total loads on the table. The graph shows a deviation from this latter assumption since the curve for the 0.030 inch lining is

considerably higher than would be expected. The thicker, 0.140 inch lining, however, does exhibit a more uniform curve, thus suggesting the possible presence of minor inaccuracies in the seating of the thinner lining.

Simply Supported Beam.—When the simply supported beam and window apparatus was tested, the load transmitted through the linings to the window was about 7 per cent of the assumed load (Fig. 5). This trend continues that shown

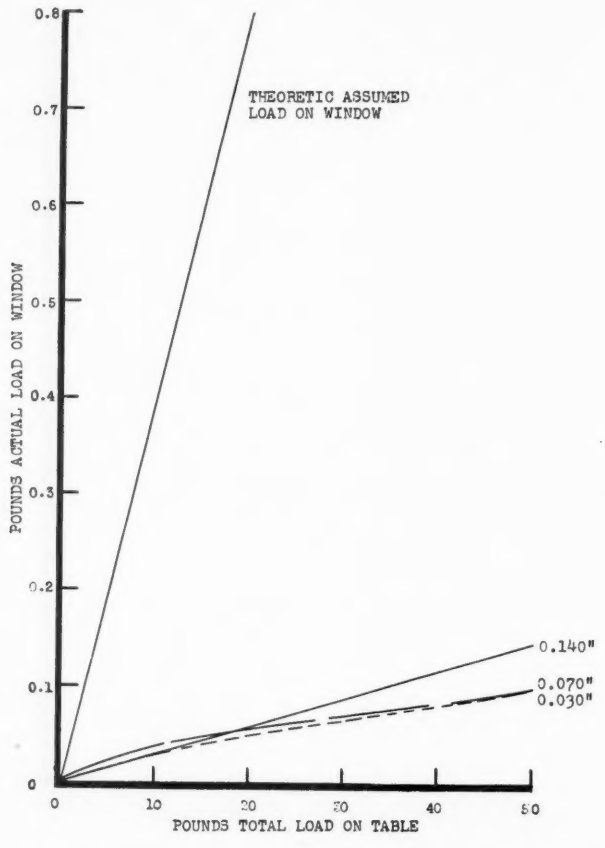

Fig. 5.—The relation of the actual load on the window to the total load on the table when a simply supported beam was used as the window mounting is shown when linings of 0.140 inch, 0.070 inch, and 0.030 inch were used.

with the cantilever beam and suggests that, whereas the lining was displaced fairly easily in the early stages of loading, as the load was increased progressively the lining was displaced less easily and transmitted a smaller proportion of the total load to the window.

The curves for the three different linings were close together. That for the thickest lining was the steepest, and the other two were practically superimposed upon each other.

Two Vertical Gold Beams in Tension.—The thickest lining (0.140 inch) was the only one that gave a progressive transmission of load throughout the entire range of the test (Fig. 6). The thinnest lining (0.030 inch) lagged behind the thickest from the outset in transmission, but beyond a load of 15 pounds ceased rapidly to transmit any extra load. The medium lining (0.070 inch) curve followed the theoretic curve closely to a load of 7.5 pounds, but above this level soon failed

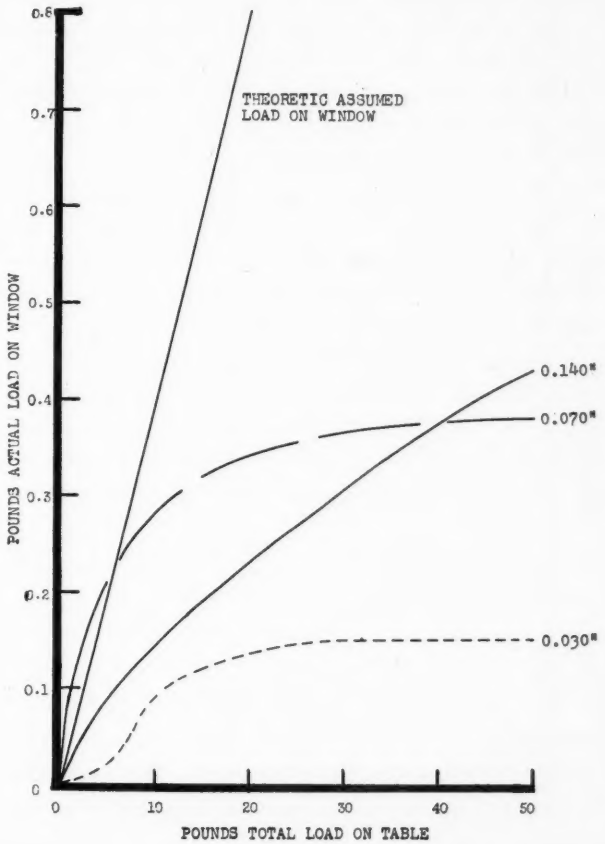

Fig. 6.—The relation of the actual load on the window to the total load on the table with a window mounting of two gold beams in tension is shown when linings of 0.140 inch, 0.070 inch, and 0.030 inch were used.

to transmit more load. The unexpected initial behavior of this lining was considered to result from local inaccuracies of contact between the window and the lining.

Although the results of this method of window support are superior to those of previous methods, the accuracy (of the usable portions of the curves) is still as low as 20 to 30 per cent. The indication is, however, that rigidity produces increasing accuracy.

Four Plastic Posts.—The results obtained (Fig. 7) were surprising. Not only did the increased rigidity produce a greater transmission of the load through the linings, but the load increased beyond the level of the theoretic assumed load, increasing with the thickness of the lining. Measured in terms of percentages of the theoretic assumed load, the loads transmitted through the linings were: 0.030 inch, 175 per cent; 0.070 inch, 250 per cent; and 0.140 inch, 375 per cent.

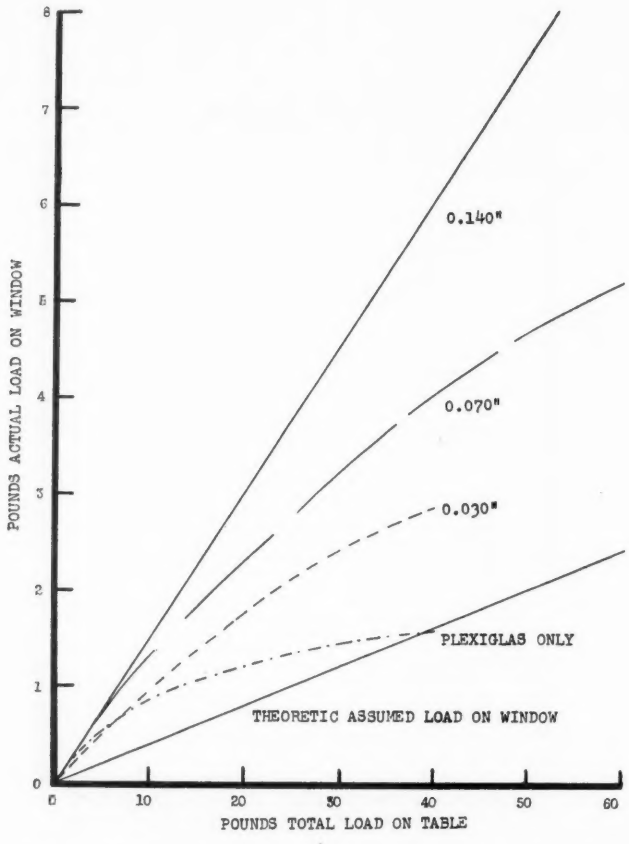

Fig. 7.—The relation of the actual load on the window to the total load on the table when four plastic posts were used as the window mounting is shown when linings of 0.140 inch, 0.070 inch, and 0.030 inch were used.

In an attempt to discover the reason for these unexpectedly high readings, the experiment was repeated using a rigid sheet of Plexiglas (with no soft lining) to transmit the load. Readings slightly in excess of of the control curve were recorded from this test (Fig. 7). The surfaces of the window and table had been ground carefully with fine emery paper to make them as level with one another as possible. The fact that a reading was obtained when loading through the hard and smooth Plexiglas sheet shows that small irregularities, even of the order of a few micro-inches, are sufficient to have a marked effect on a rigid window mounting.

COMPARISON OF RESULTS

Variations in Type of Window Mounting.—For a given load range, the experimental results indicate that the more rigid window mountings support a greater amount of the load transmitted through the soft linings than do the less rigid mountings. Comparative figures expressed as percentages of the theoretic assumed load are: cantilever beam, 1 per cent; simply supported beam, 7 per cent; two gold beams in tension, 20 to 30 per cent; and four plastic posts, 175 to 375 per cent.

The first three mountings, being less rigid than the fourth, followed the theoretic trend. In the fourth method, however, the table with plastic supports produced results from 175 to 375 per cent of the theoretic load. The construction of these supports formed a mounting that was nearly as rigid as the table itself; therefore, any difference in level between the window and table, even though only a few micro-inches, produced marked inaccuracies. When the window mounting is nearly as rigid as the table, it becomes necessary to consider any bending or deflection of the table top itself, which complicates the analysis of the problems. It would be practically impossible to perfectly align irregular and complex curved surfaces, such as are found in a clinical denture, within a limit of 2 or 3 micro-inches.

Variations in Thickness of Linings.—With a few exceptions, which are due to technical and experimental difficulties, the different linings appear to transmit approximately equal proportions of the load during the early stages of loading. As loading progresses, however, the thinnest lining is the first to falter and transmit progressively smaller proportions of the load; the intermediate lining is next, with the thickest lining remaining the most effective over the greatest range of loads.

Variations in Load Range.—The accuracy of the results obtained varied considerably as the magnitude of the load varied. In general, as the load increased, the accuracy decreased.

CONCLUSIONS

1. A basic shortcoming in this approach to measuring masticatory force is that displacement of the window is necessary for any strain reading to be recorded. It is this very movement that results in a portion of the window load being transferred to the surrounding area of the table (or denture), thus invalidating any reading that is obtained. Where it is desired to measure a force by means of a strain gauge, the strain-gauge mounting must be mechanically "in series" with the rest of the equipment so that the whole load passes through the gauge. Any arrangement where the gauge mounting is "in parallel" with other load-bearing members will result inevitably in a shifting of the load if any displacement occurs, and inaccurate information will result.

2. Wide variations in window-load readings result from variations in thickness of the linings. Similarly, it can be assumed that the wide variations in tissue thickness in the mouth will produce variable and unpredictable results when tests are carried out clinically. This unknown factor of tissue thickness makes any attempt to calibrate the strain gauge impossible.

3. These shortcomings cast doubts upon the validity of results obtained when using this method for clinical studies.

SUGGESTIONS FOR FUTURE STUDIES

The underlying weakness of the measuring device investigated is that displacement of the window causes a transfer of part of the load to the surrounding table (or denture). If the window could be returned to its starting position, it would once more bear its fair share of the load. The force required to return the window to this initial position would be equal to the load on the window; therefore, a hydraulic system was designed theoretically (Fig. 8).

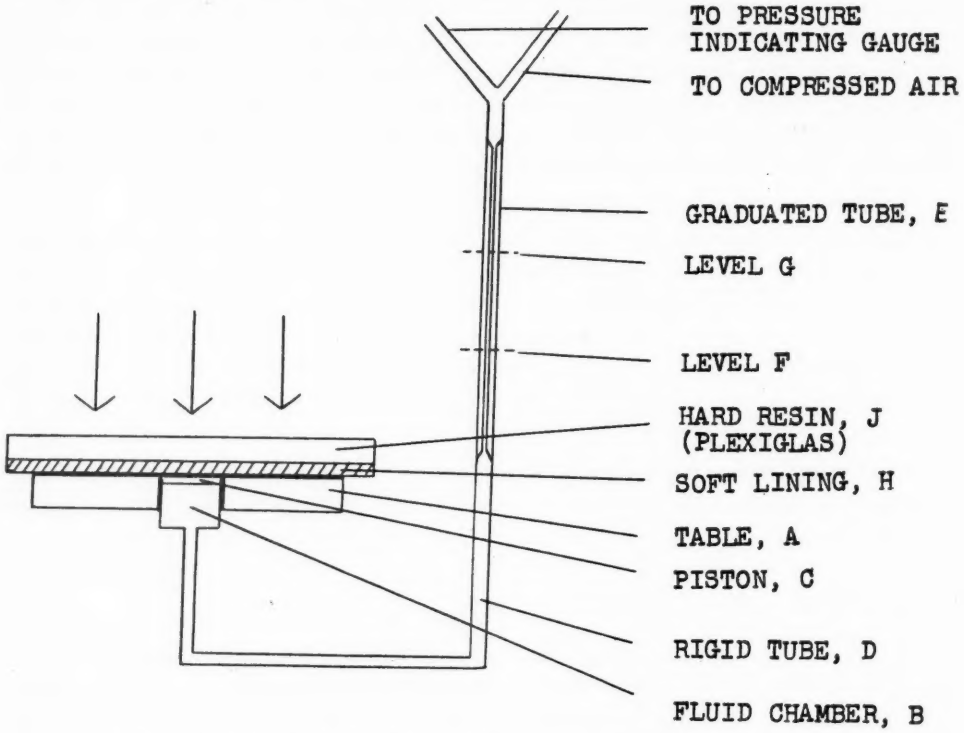

Fig. 8.—A diagram of a hydraulic measuring system suggested for future studies.

A table *(A)* has a central hole which is filled by a fluid chamber *(B)*, the upper surface of which consists of a piston or rubber diapragm *(C)*. The piston is connected by a rigid tube *(D)* to a graduated glass tube *(E)*, and the system is filled with fluid to an arbitrary level *(F)*.

A load may be applied through a soft lining *(H)* backed by a rigid plate *(J)*. The load will depress the piston or diaphragm *(C)* and drive the fluid up to a higher level (such as *G*). If sufficient pressure is now applied to return the level of the fluid to its original starting point *(F)*, this will return the piston *(C)* to its starting position and ensure that it is once more bearing its fair share of the load on the table. The pressure used will indicate the exact load upon the window. When this

technique is used in the mouth, the diaphragm (mounted in the tissue surface of the denture) would be connected to the extraorally placed measuring device by means of a rigid metal tube running around the buccal and labial surface of the denture in the same manner as the tube on a water-cooled impression tray.

This same basic reasoning can be expanded into an electronic system which should be capable of operation in a dynamic situation as well as a static laboratory problem. If the central hole is covered with a strain gauge-bearing diaphragm, the strain reading would indicate also the position of the diaphragm. The strain gauge could then control an electric amplifier which, in turn, would drive an electromechanical transducer so connected that the diaphragm would always be returned to its original position. The electric power output of the amplifier would then be an indication of the force necessary to return the diaphragm to its starting position and would indicate the load on the window.

SUMMARY

An investigation into the validity of a proposed method for measuring the masticatory forces transmitted through a denture base has been presented. Laboratory equipment was built to represent a denture in the mouth. Known loads were applied, and measurement of the load was attempted.

The results obtained were analyzed and compared from the following standpoints: (1) variations in types of window mountings, (2) variations in thickness of lining, and (3) variations in load range.

I express my appreciation to Dr. Edwin E. Henry for his guidance, technical assistance, and encouragement. Dr. F. Peyton has offered much valuable advice, and Dr. O. C. Applegate and Dr. R. H. Kingery have made many helpful suggestions. I should also like to thank Mr. J. H. Lee and other members of the staff of the Institute of Dental Surgery for their assistance in the preparation of this article.

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AN EVALUATION OF THE SUPPORT FOR THE REMOVABLE PARTIAL DENTURE

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THE SUPPORT for a dental prosthesis can come from but one oral structure—the alveolar process[1] of the upper or lower jaw.[2] Between the occlusal table of the prosthesis and the alveolar bone, however, are oral structures which are pliant or yielding. These will be found to play a very important role in the attainment of support from the underlying bone.

One such interjacent structure is the highly specialized periodontal membrane which surrounds the abutment root and through which the occlusal work load must be transferred. The second of these intervening structures lies over the residual ridge and the circumjacent basal bone. It is upon this pad, which varies in its tissue composition, that the base of an extension partial denture is so adapted that occlusal stresses may be passed.

THE TRANSFER OF OCCLUSAL LOADS

The most essential difference between a "tooth-borne" prosthesis and one which is classified as "tissue-supported" is not one of support, because both ultimately are supported by alveolar bone. The real difference is the dissimilar manner in which the intervening structure transfers the occlusal forces passing through it from each type of appliance to the foundation bone.

When the appliance rests upon a tooth at each terminus (Fig. 1, *A*), work loads pass from the abutment roots via the principal fibers of the enveloping periodontal membrane to the lamina dura of the alveolar walls. These fibers are stretched from a relaxed to an extended length as functional loads are received and transferred. The tissue-supported appliance, on the other hand, passes its occlusal burden through its base to the pad (mostly fibroelastic tissue) which covers the bone. But,

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in this instance, instead of the fibers of this structure being stretched, they are rendered compact enough to convey the stresses to the subjacent bone. During the interval of this work transfer, surface circulation in the mucosal pad is stopped.

Two dangers accompany this latter type of work transfer. First, unless the period of ischemia is brief, there is danger of tissue damage because of interference to normal circulation. Second, there may be overload to the extent that trauma of the mucosal structures results. Such localized damage is rather frequent when occlusal force is passed by way of a denture base, because the mucosa does not have sufficient proprioceptive enervation. In this, it differs from the periodontal membrane in which this protective mechanism is highly developed.

There are very important reasons for always making an utmost effort to save a remaining posterior tooth for abutment service (Fig. 1, *A*). First, the abutment tooth is supported in a hammocklike net of fibers.[3] This highly specialized periodontal membrane has been developed and arranged to perform just such heavy functional work; whereas with the extension denture base (Fig. 1, *B*) the function of transmitting the occlusal work is thrust upon the mucosal pad through the prosthesis and is one quite remote from that for which these tissues were originally intended.

A second reason for preferring tooth support for a removable prosthesis is that this strong periodontal membrane has been equipped with a defense against overload by having a keen proprioceptive enervation.[4] When overload is approached, stimuli proceed from this membrane to the muscles of mastication via the central nervous system. This involuntary reflex precedes any sensation of pain or discomfort and deters the responsible musculature from applying excessive force. This protective function is thought to be one important factor in the excellent record of the fixed tooth-borne prosthesis.

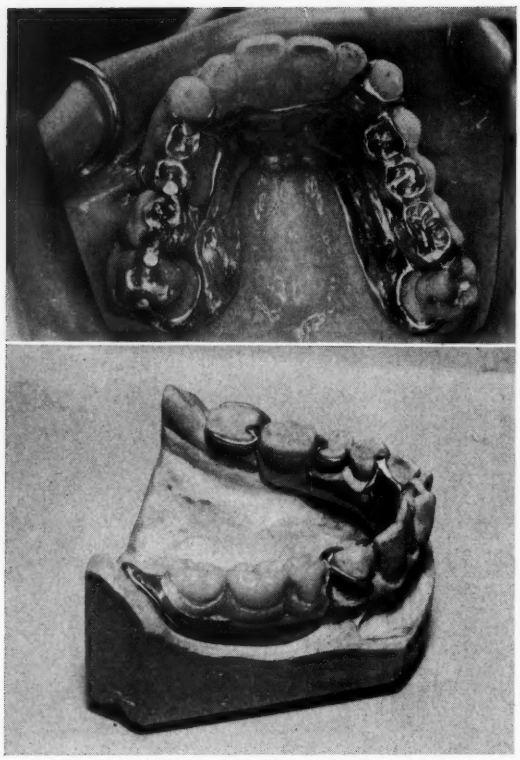
A third reason for preferring an abutment tooth rather than an extension denture base for transmitting occlusal force is that the stress is transferred more safely by stretching instead of compressing tissue fibers. In the latter process, because of the habit of bruxism, the condition of ischemia may be continued for long periods of time. There is little doubt that the forces so generated are much more destructive than those produced in the functional activities associated with mastication.

SUPPORT FOR AN EXTENSION-BASE PARTIAL DENTURE

The free-end denture-base appliance (Fig. 1, *B*) is usually regarded as having two sources of support—one from selected abutment teeth and one from the denture base. While the tooth component of this dual support for the extension partial denture is the lesser, it nevertheless is most important. This is particularly true in the lower Class I partial denture, where the supporting ridge area may be very limited and the ridge form may be extremely poor.

Two methods of transmitting the force load to the foundation bone are utilized in obtaining dual support for an extension-base partial denture. The tooth-borne portion is passed through the abutment root and the periodontal membrane. This process of work transfer utilizes the *stretch mechanism* as in the tooth-borne prosthesis. A much larger portion of its work load is sent through the base and subjacent mucosal pad to the alveolar process. The hazards of this latter method have been

A.



B.

Fig. 1.—*A,* A tooth-borne removable partial denture which is an example of the valuable *cross-arch* stabilization which may be derived from a bilateral design. When teeth have been weakened by cervical bone loss, they still may be able to sustain the occlusal work loads, if these stresses are applied in an axial direction. But, in such situations, a unilateral appliance (fixed or removable) would fail because of the periodontal overload induced by *lateral tilting* of the weak abutments. *B,* The extension-base partial denture receives a *dual* support—some from the abutments, which bound the edentulous areas, but (on the right) mostly from the residual ridge together with the buccal and lingual areas of basal bone over which its base is related. (From Applegate, O. C.: Essentials of Removable Partial Denture Prosthesis, Philadelphia, 1959, W. B. Saunders Company.)

Fig. 2.—These bicuspid teeth have assumed the work of the molars missing for many years. Note that the bone is of the *less dense* type, but has been maintained rather favorably in spite of the overload. This is a frequent clinical finding. It is the very dense bone that often proves to be less stable.

noted. The advantages of stress transmission by way of the abutment tooth can be partially attained, but in extension-base partial dentures there are certain additional difficulties to be avoided. When such a denture base loses its stability, there will be tilting of the abutment tooth in its alveolus, with lateral or proximal areas of compression in the periodontal membrane.[5] The transfer of work loads by the periodontal membrane can be done with complete safety only when the stress loads are parallel to the long axis of the tooth root. If zones of compression are established in the periodontal membrane by abutment tilting, and this condition is continued for minutes (as it may be in bruxism), severe damage to the alveolar bone may be caused.[6,11]

THE URGENCY OF BONE EVALUATION

With this basic concept of the essential part that the bone structure is to play in attaining a continuing success in partial denture service, it becomes evident that its critical evaluation should be made before any plan for mouth rehabilitation is considered. No factor has greater bearing upon the probable longevity of partial denture service than the degree to which the alveolar structures are satisfactorily maintained. How may this be predicted with reasonable certainty? The evaluation of a patient's alveolar bone stability is perhaps the most critical step in oral diagnosis and treatment planning prior to the rendering of partial denture service. On the basis of this analysis, it may become apparent that changes must be made to compensate for a subnormal tolerance of the alveolar structure. If such physical conditions are known *in advance,* measures may be taken which will still make possible reasonably acceptable service for most patients who show such subnormal bone maintenance.

BONE DENSITY AND ITS STABILITY

Many have held that this estimate of the probable bone reaction to prosthetically induced work loads can be made on a basis of bone *density.* A determination based on this single factor has certain weaknesses which do not make it dependable. There will be a wide difference of opinion as to what is meant by *dense* and as to when a roentgenogram of alveolar bone represents one degree or another of bone density. Also, the apparent density of an area may be made to seem different by altering the x-ray technique. Changing one or more of the following factors will alter the film appearance so as to result in a different interpretation of the bone density portrayed: time of exposure, target-film distance, angulation, developing and fixing time, temperature, or technique.

Finally, there is difference of opinion as to whether dense or less dense bone will accept added stress loads best or with least tendency toward atrophic change. Good clinical results can be shown in both dense (hypercalcemic) and less dense (hypocalcemic) bone. The clinical observations have shown that the less dense alveolar process (Fig. 2) will generally be *less likely* to show unfavorable change following the insertion of a partial denture. This seems a perfectly reasonable expectation. Bone undergoes change constantly. Resorption of old bone and the formation of new bone progresses continuously throughout life.[7] A less highly calcified,

or less dense, bone structure is more organic in structure. This would be conducive to a normal rate of bone maintenance because its rebuilding would be facilitated. For these several reasons, it must be concluded (1) that the degree of calcification is a dependable measure neither of bone stability nor of its ability to withstand added functional demands, (2) that because bone density varies with any change in x-ray technique, the *apparent* density, as roentgenographically portrayed, is an uncertain measure in bone evaluation, and (3) that relative density may vary greatly among patients whose bone stability has been proved by having provided adequate base support over a long period of years without resorptive change.

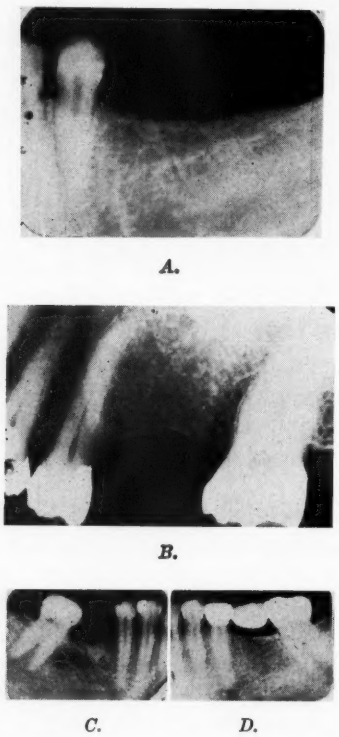


Fig. 3.—Three kinds of "index areas." All have received an overload for varying lengths of time with only little damage to the supporting bone. *A*, Teeth adjacent to an edentulous area. *B* and *D*, Abutment service has been supplied. *C*, A tipped tooth which adds a magnified, compressive stress on the mesial alveolar wall. (From Applegate, O. C.: Essentials of Removable Partial Denture Prosthesis, Philadelphia, 1959, W. B. Saunders Company.)

ALVEOLAR RESPONSE TO PREVIOUS OVERLOADS

After many disappointing experiences in trying to estimate the quality of bone on the basis of its apparent density, a more dependable method was sought. As a result, I have advocated that bone appraisal be made on a basis of the response of the alveolar structures to an increased work load. These are the areas around individual teeth which have sustained a greater than normal work load for a period of a few years. They may be properly called "index areas."

The most obvious index area is to be found in any dental arch from which posterior teeth are missing. The tooth which bounds such an edentulous area,

anteriorly, will have been subjected to an increased work load. If no molars remain posterior to the area, all of the occlusal forces generated on that side of the arch will be focused on the bicuspids. Even when the second molar remains, it will usually tip mesiolingually, and an ever increasing share of the load will shift to the anterior teeth. So, the alveolar bone around the teeth adjacent and anterior to a posterior edentulous area has been subjected to a greater than normal work load.

Another index area is that surrounding an abutment for a fixed or removable tooth-borne partial denture or an abutment for the tooth-supported end of an extension-base partial denture. This addition of stress on the supporting structures is obvious.

A tooth which has tipped out of a normal vertical alignment will subject its supporting structures to increased demands on certain areas of the alveolar walls. In such instances, the stresses (perhaps already made greater by faulty occlusal relations) will be increasingly magnified as unfavorable leverage develops in ratio to the degree the tooth inclines away from vertical position.

Known areas of greater than normal work load on supporting alveolar bone may be logically considered as index areas of the patient's probable reaction to the anticipated functional loads of the denture. These are (1) alveolar bone around the teeth adjacent to an edentulous area, particularly the anterior boundary teeth (Figs. 2 and 3, *A*), (2) the bone around a tooth which has served as an abutment for a fixed prosthesis (Fig. 3, *D*) or a removable prosthesis (Fig. 3, *B*), (3) the area about a tooth which has been subjected to the added work resulting from malocclusion, and (4) certain limited areas of the alveolar walls which support a tipped tooth (one which has inclined out of normal vertical relation) (Fig. 3, *C*).

CLINICAL PROCEDURES BASED ON BONE EVALUATION

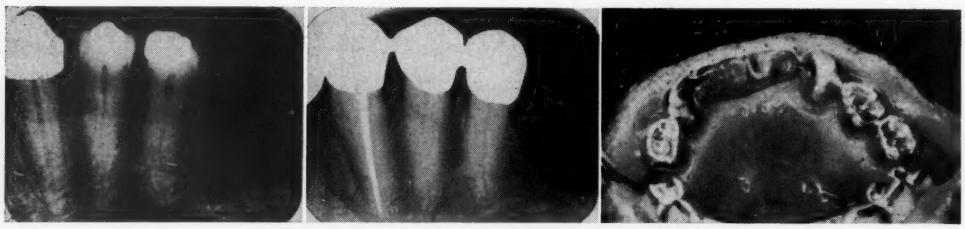
When there has been good bone response in such index areas, the teeth to be used as abutments may be expected to support the added load without injury to the bone, in spite of the greater than normal demand. If the span is short and/or the occlusal load light, a unilateral tooth-borne prosthesis will give a fine record of service as the fixed partial denture so frequently has done (Fig. 3, *D*).

If the response in key areas has been only moderately good, however, indicating a lessened tissue tolerance and/or a lowered metabolic function, caution is indicated. For this situation, or where there has been too much previous loss of alveolar bone around a prospective abutment, three precautions are to be followed[6]: (1) two or more adjacent teeth may be splinted together to serve as abutments (Fig. 4), (2) a bilateral removable (instead of a unilateral) prosthesis may be used to attain the leverage advantage of cross-arch splinting (Fig. 5), and (3) the occlusal table may be narrowed to reduce the work load (Fig. 6). Frequently, all of these measures may be used in a single instance.

EVALUATION OF THE EDENTULOUS AREA IN EXTENSION-BASE SITUATIONS

The proposed analysis of alveolar response in certain index zones may be made when an extension-base partial denture is used. Frequently, most of the posterior teeth were removed many years before and not replaced. As a result of

disuse, the alveolar residual ridge may have become greatly reduced in size. It may have been lowered toward the buccal and lingual levels of the circumjacent basal bone (Fig. 7,) especially in mandibular, partially edentulous situations.



A. *B.* *C.*

Fig. 4.—*A*, The lower bicuspid-cuspid area (about 1950) before these teeth were splinted (1952). *B*, The same area in 1957 after it had served as one abutment for an anterior fixed prosthesis and a Class I removable partial denture. *C*, The lower anterior arch as it appeared 7 years after the five abutments (two on the left and three on the right) were splinted.

Such disuse atrophy is not merely a reduction[8] of ridge height and form. It is also, a matter of the bone having become unable to tolerate subjection to a sudden return to the demands of function. If loaded after long periods of disuse, an immediate resorptive change beneath a partial denture base may be expected (Fig. 8). It has become a routine procedure to anticipate the need for "rebasing" a mandibular partial denture within a few months after it is first placed in the mouth.

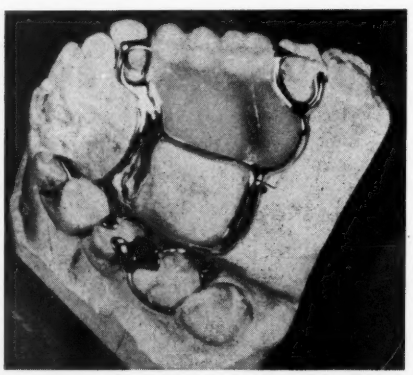


Fig. 5.—When weak teeth are used to support a tooth-borne prosthesis, they can survive the demands of abutment service only if they are stabilized by cross-arch support. They cannot withstand lateral forces because of the loss of cervical bone support. The abutments shown here have served over 15 years under extremely heavy occlusal work loads. (From Applegate, O. C.: Essentials of Removable Partial Denture Prosthesis, Philadelphia, 1959, W. B. Saunders Company.)

This is the reason that most appliances of the extension-base type have had bases made of resin instead of metal, which is more desirable except for the difficulty of rebasing. When replacing posterior teeth which are to be supported chiefly by the edentulous ridge, how may we evaluate the probable stability of such bone? Again, the study is to be centered in areas around teeth which have been subjected to more than a normal work load. How does such response, perhaps remote from the ridge area, indicate what may be expected to happen beneath the base?

An excellent maintenance of bone in the key areas around remaining teeth does not indicate *immediate* stability of ridge support. Quite the contrary, it is likely that a partial denture base may show loss of support almost immediately even when there is an excellent bone condition (Fig. 8). One of the common mistakes has been to assume that stable base support also would be assured if the roentgenograms showed fine bone maintenance around the remaining teeth. Frequently, it has

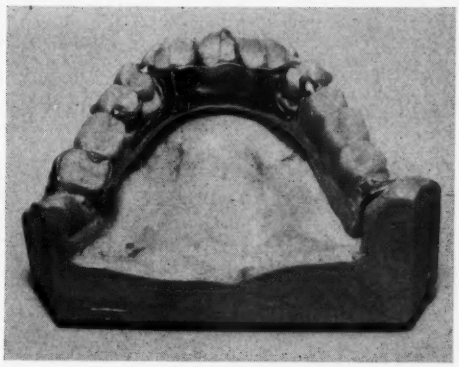
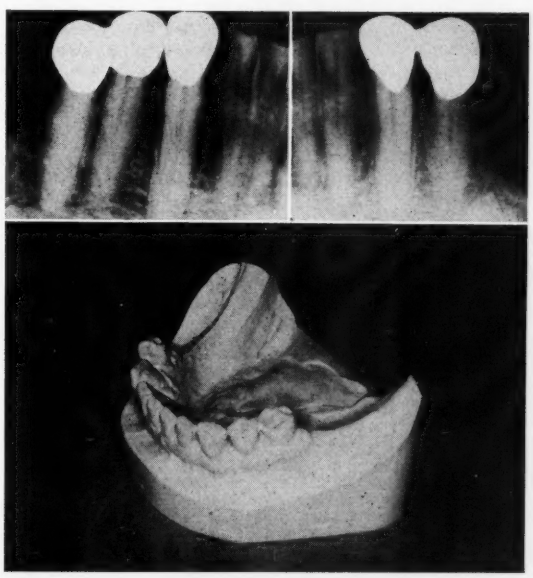


Fig. 6.—This metal base (of only average area) has remained stable for 9 years after being placed *following exercise therapy*. Note the reduction of the occlusal surfaces in their buccolingual dimension. (From Applegate, O. C.: Essentials of Removable Partial Denture Prosthesis, Philadelphia, 1959, W. B. Saunders Company.)

A.



B.

Fig. 7.—*A*, Bicuspid abutments after 17 years of abutment service. The bone level is good at age 67. *B*, Note the extreme loss of bone in the right posterior area from disuse *before* the Class I removable partial denture was placed. The bone has remained stable for this long period of time without corrections. (From Applegate, O. C.: Essentials of Removable Partial Denture Prosthesis, Philadelphia, 1959, W. B. Saunders Company.)

been said that "the missing teeth have been out long enough for the ridge to become firm." However, the bone has received little or no functional stimuli in disuse and, as a result, it is not able to support normal occlusal loads *at once.*

There is no reason for dispair in this situation. On the contrary, if there is this dependable evidence of normal maintenance of the alveolar process in one area, there will be a similar ability to restore the bone of the edentulous ridge to stability *when a functional need for it has been re-established.* It is possible to predict the rate of this reconditioning process. This estimate is based on how nearly normal the bone of the areas of heavily worked teeth has been maintained. The better the bone maintenance, the faster will be the re-establishment of ridge stability.

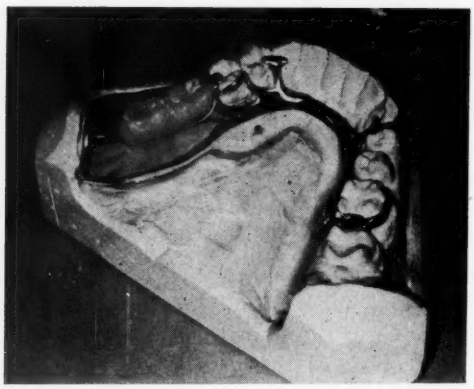


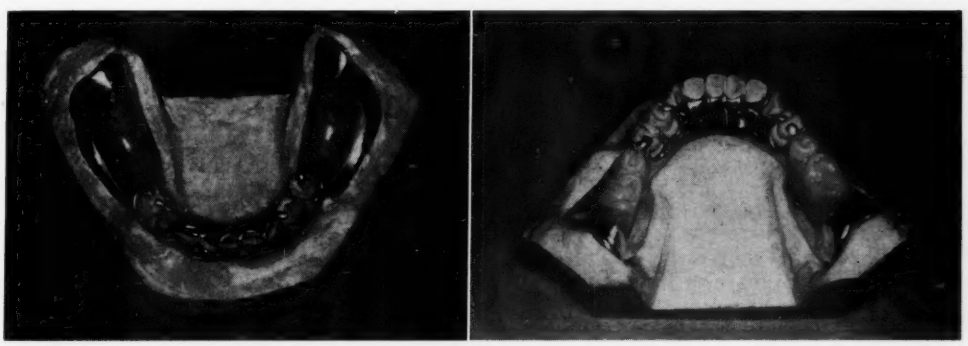
Fig. 8.—This Class II removable partial denture showed a loss of base stability within a few weeks. The bone maintenance around the remaining teeth was excellent and the patient a vigorous, healthy man. In spite of a large base and balanced occlusion, the loss of basal support followed quickly. The base had been placed on a residual ridge which had had no function for many years and was given an immediate functional load *without previous exercise therapy.* (From Applegate, O. C.: Essentials of Removable Partial Denture Prosthesis, Philadelphia, 1959, W. B. Saunders Company.)

EXERCISE THERAPY BEFORE PROSTHETIC USE

Clinically, the possibility of stimulating return of an unused residual ridge bone, by mild exercise, to a condition in which it will have adequate supportive ability has been demonstrated.[9] The "exercise base" should cover the maximum area and should be so constructed as to spread the work load as uniformly as possible over the structures of the basal seat. If the base is of metal (Fig. 9), the advantages of thermal stimulation of the subjacent tissues and conduction of body heat away from them are added. The proper use of this exercise base (without teeth) is most important. The exercise should be by *mild* digital pressure, repeated often but for only brief periods. This can be accomplished by rapid opening and closing on a finger which is resting on the base near the abutment area.

This type of action can produce a force which will be similar in direction to the occlusal force loads to be applied later. Frequent hot and cold drinks add thermal stimuli to those induced by the mild biting force. It is most important that the *stimuli be within the limits of a tissue tolerance* which has been temporarily lowered through long disuse. It is sometimes difficult to have the patient understand that he

must not bite too hard and must not maintain the pressure except for very brief intervals. Exercise should be continued for a minimum of about 8 to 12 weeks for patients showing an excellent bone maintenance potential. A longer course of exercise therapy is needed when there is evident lack of ability of the patient to maintain the bone structure. Smith* has substantiated this in a 2-year study which is not yet complete. By repeated roentgenographic evaluation, he is able to offer supportive evidence that areas of previously unused bone can be reconditioned (Fig. 10). In a series of clinical studies, he found that after the introduction of a mild work stimulation there was bone change. This change was evidenced by the bone becoming more resistant to the passage of x-rays in a selected test area. Using



A. *B.*

Fig. 9.—*A* and *B*, In contrast to the situation seen in Fig. 8, this Class I removable partial denture was placed (in 1956) after the posterior teeth had been missing for many years. It was worn as an exercise prosthesis *(A)* for about 4 months before the teeth were added. After 2 years, the metal base was completely stable. (From Applegate, O. C.: Essentials of Removable Partial Denture Prosthesis, Philadelphia, 1959, W. B. Saunders Company.)

a modification of Richards'[10] technique, Smith utilized a specially constructed apparatus by which the patient's head position could be definitely re-established for successive measurements. The film was supported in exactly the same position, and the x-ray was directed at exactly the same angle. The x-ray technique employed provided the same target-film distance and the same exposure time. A retrogressive change was detected, which recurred consistently after the application of a work load but varied in degree with different patients.

This decline in the bone condition seems to last about 8 weeks, and it is followed by a gradual reorganization. The bone returns, within a varying number of weeks, to a status which is better than the structural quality shown at the time the exercise appliance was inserted. In patients with good bone, this alteration seems to level off in about 8 to 14 weeks, and the bone condition then remains the same unless the stimulation is interrupted. When stability of the bone is achieved, the missing teeth are placed on the appliance, and it is inserted for service. A resorptive loss beneath an extension denture base has not been seen when the patients have received preliminary exercise therapy.

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SUMMARY

Preliminary evaluation of the support for any removable dental prosethesis must be based on the premise that the alveolar process is the origin of this support.

It is suggested that the true difference between the tooth-borne and the extension-base types of prostheses is the different manner in which the work load is transmitted by the pliable structure which lies between the bone and the occlusal table of each type of restoration. In tooth-borne appliances, this work transfer is accomplished by the stretching of the fibers of the periodontal membranes from their relaxed to their extended lengths. In extension-base prostheses, the occlusal burden passes through the base, into and through the mucosal pad to the foundation bone.

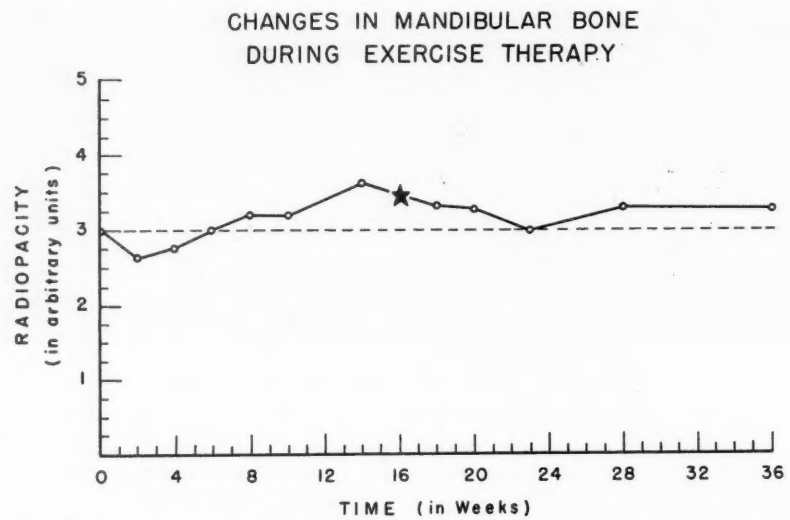

Fig. 10.—A typical graph of bone changes induced by mild exercise on partial dentures of the type seen in Fig. 9. These intermittent measurements were obtained by radiopacity determinations repeated in the same area (about 10 mm. posterior to the right abutment). This woman (52 years old) had maintained a normal bone level in areas of teeth which were sustaining an occlusal overload. Extractions in the areas of study had been made about 15 years earlier. Teeth were added after 16 weeks of exercise therapy (the star indicates this point). Twenty weeks later, the bone showed more radiopacity (more resistant to the x-rays) than when the appliance was first placed. The resin base has remained stable. (Courtesy Dr. Franklin W. Smith, Ann Arbor, Mich.)

Emphasis has been placed upon the facts that the mucosal pad must be compact to transmit a work load and that since bruxism may be responsible for prolonged occlusal contact, the resulting stoppage of circulation would be made more likely in the free-end appliance and it can be the cause of serious damage.

It is noted that the periodontal membrane is provided with proprioceptive enervation. This is seen as another reason to prefer the transmission of work by an abutment tooth rather than by an extension base. Because it is biologically and physiologically more normal and more likely to be kept within tissue tolerance limits, a tooth-borne prothesis is to be preferred.

There is ample evidence that bone stability can be evaluated most dependably by noting its past reaction to increased work loads which have existed for some period of time. Reliable index areas of alveolar bone have been found around (1)

teeth which are the anterior boundaries to posterior edentulous areas, (2) teeth which have served as abutments, (3) teeth which have sustained trauma as a result of occlusal imbalance, and (4) teeth which have become inclined out of their normal vertical position.

When there has been a normal maintenance of alveolar structure in spite of increased work in such index areas, it may be expected that the prosthetically increased functional load will be absorbed without exceeding the tissue tolerance of the host. But, where there has been loss of alveolar process in the index areas, the prospect of added work is unfavorable *unless* special protective measures are taken.

Even when there is evidence of a *normal replacement* of bone elements as they are destroyed by work, the alveolar bone will not have been maintained in edentulous areas elsewhere in the same arch where *disuse* has existed for long periods of time. In such cases of *disuse* atrophy, a reconditioning of the bone is necessary to restore it to a stable condition before a normal functional work load can be supported. In almost all cases of record, the need for rebasing has been eliminated in this way.

Exercise stimulation by light, intermittent biting on a finger resting upon the appliance base (from which the teeth have been omitted) has been found to stimulate bone reorganization and to return areas of disuse to normal.

Where alveolar subnormality is evident from the reaction in the index areas, other precautionary measures must be taken. These include (1) splinting of two or more teeth to form multiple abutments, (2) reducing the occlusal table to provide a lessened work load, and (3) increasing the period in which the exercise base is used to recondition the alveolar process about one-third.

Prosthodontists must become more aware of the limitations of some patients to support a dental prosthesis adequately. The restoration of occlusal function must be tempered to the probable ability of the individual to maintain the only oral structure which can give appliance support—the mandibular or maxillary bone. It seems reasonably certain that bone maintenance is reliably predictable in most instances.

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REST AREA PREPARATIONS FOR REMOVABLE PARTIAL DENTURES

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THE USE OF RESTS with removable partial denture prostheses has been developed since rests were first described by Bonwill[1] in 1899. Kennedy[2] has credited Bonwill's technique as the one from which clasping procedures in their present form were derived. Part of his work described the use and importance of rests and rest areas on the abutment teeth.

PERIODONTAL CONSIDERATIONS[3]

The removable partial denture is borne by teeth and tissues. Teeth are better able to withstand the forces of occlusion and mastication than the soft tissues overlying the residual alveolar ridge in a partially edentulous mouth. Any application of force to the abutment teeth will be transmitted through the teeth to the periodontal membrane, whose individual fibers are better able to absorb the forces which act in an axial direction. Less than one-half of the fibers in molars and premolars are available to resist lateral displacement. With increase in age, the periodontal membrane is less able to withstand lateral forces applied to it. Axial stresses have been found to stimulate a proliferation of fibers within the periodontal membrane, and a thicker lamina dura has resulted. Horizontal stresses have also been found to increase the number of periodontal fibers when applied intermittently and within physiologic limits, but these limits are difficult to judge in individual patients.

The most favorable prognosis for removable partial dentures is with the entirely tooth-borne appliance, where occlusal rests are placed to transmit stresses axially to the teeth. These rests should cover an adequate area and be positioned correctly in relation to the surfaces of the teeth. Wide distribution of the load over contiguous teeth, through splinting either with soldered restorations or the use of embrasure hooks and extended clasp arms, has been advocated when the teeth needed for support of the prosthesis are in poor periodontal condition.

Certainly, the extent of rest area preparation is dependent upon the amount of occlusal force the patient is capable of producing. For this reason, the patient's oral musculature, and to some extent the amount of attrition of the teeth, will be the factors governing the size and number of rest areas required for each restoration.

This essay won the first prize of $500 in the Prosthetic Essay Contest for Senior Dental Students sponsored by the American Denture Society in 1958-1959.

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FUNCTIONS OF A REST

The functions of a rest have been obtained from several authors.[1,4-11] The following functions govern the selection of the rest area site and determine the type and strength of rest required. They are: (1) to provide resistance against occlusal load, (2) to direct forces of mastication parallel to the long axis of the abutment tooth, (3) to maintain the retentive terminal of the clasp arm in its intended position, (4) to prevent the denture base from seating past its intended position, (5) to give lateral stability against undue horizontal stresses to the soft tissue of the ridges, (6) to deflect food away from the area of contact between denture and tooth, (7) to maintain occlusal contact with opposing teeth, (8) to prevent extrusion of abutment teeth, (9) to help where tipping or rotation of a tooth has impaired functional occlusion, (10) to provide indirect retention with auxillary rests, (11) to close a small space between teeth by bridging that space with occlusal rests, and (12) to act as a rigid reciprocal arm of a retaining clasp.

MOUTH PREPARATIONS IN GENERAL

Many articles have been written on the subject of mouth preparations. Briefly, they begin with a thorough intraoral examination correlated with mounted study casts and full-mouth roentgenograms. The patient's dental and medical history should be considered in planning the design. Equilibration of the remaining teeth must be carried out. Needed restorations should be planned with regard for abutment tooth contours for favorable clasping conditions, as indicated by a survey of the study casts. Rest area sites must be selected with regard to achievement of maximum stability and with regard for the position and periodontal condition of the teeth upon which they will be placed. The rest areas may be prepared in sound enamel or as part of an inlay or crown restoration. Where the patient's economic problems are a factor, rest areas have been prepared in silver amalgam restorations, but this should not be done as a rule.

SELECTION OF THE REST AREA SITE

Every clasp must have a rest to maintain the clasp arms in the proper infrabulge position.[1,5] Beyond this statement there is no specification as to the number of rests needed to support each individual restoration. By custom, most rests are placed on the proximal surface of the abutment tooth next to the space that will be filled with the prosthesis. This may not be the most advantageous site.

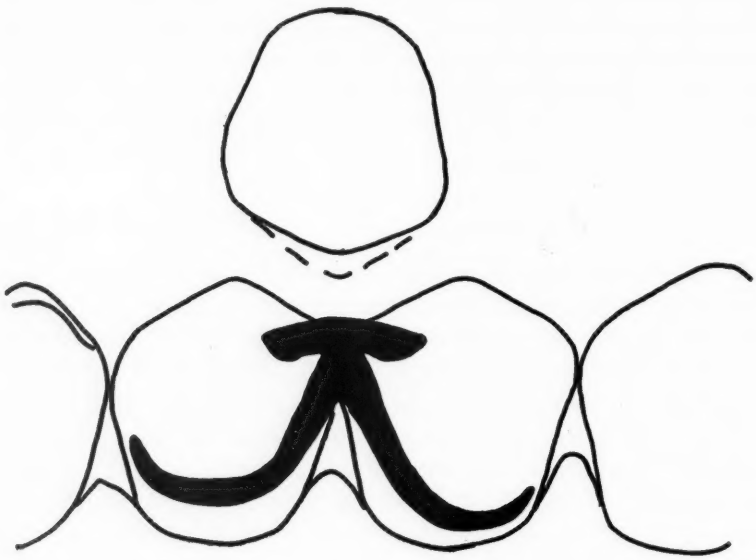
In the case of mesially tipped abutment teeth, especially last molars, it would be better to place the rest area at the distal side of the tooth, in order to place the forces of occlusion over the root mass. Forces of occlusion acting on a mesially placed rest area would tend to further tip the tooth.

Some premolar abutment teeth may have tipped distally, with a resultant diastema between them and the next adjacent tooth. In this situation, a rest designed to fill the diastema and seat into rest areas on both teeth will not only give added stability, but will prevent food impaction into the diastema.[6] A modification of this rest can be utilized with unilateral, distal-extension partial dentures when used

between the premolars or the second premolar and first molar of the opposite side[11]; however, the preparation is a double occlusal rest area and usually involves relief of the opposing cusp tip (Fig. 1).

Rest areas for indirect retention are usually prepared similarly to methods outlined later in this article for incisal and occlusal rests, but they may be nothing more than an embrasure hook[11] which is prepared by cupping two adjacent anterior teeth at their contacting incisal angles (Fig. 2).

Fig. 1



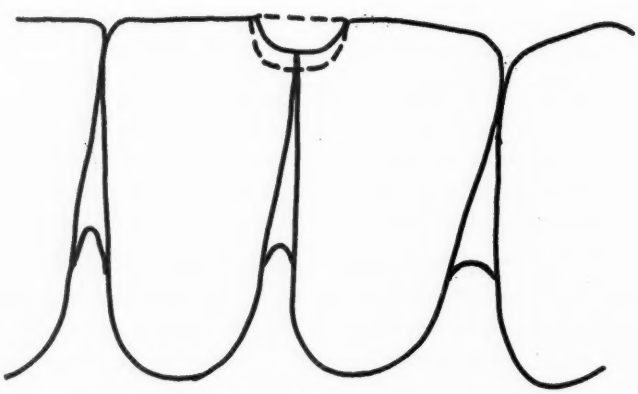


Fig. 2

Fig. 1.—A stabilizing rest placed between premolars on the side opposite a distal-extension denture base. Occlusal rest areas are placed in both teeth, and the opposing cusp tip is ground for relief.

Fig. 2.—An embrasure-hook rest area preparation in a lower central and lateral incisor. The dotted line indicates the amount of metal the hook will display.

Rest area sites determine the fulcrum line in distal-extension partial dentures[12]; that is, they are the pivot around which the distal extension will move under the forces of mastication. The denture also moves around this pivot during the unseating phase of mastication. The unseating leverage (the distance between the fulcrum line and the end of the distal extension) must be counteracted by the seating leverage (the distance between the fulcrum line and the indirect retainer rest area). The more anteriorly the rest areas are placed, the greater is the unseating

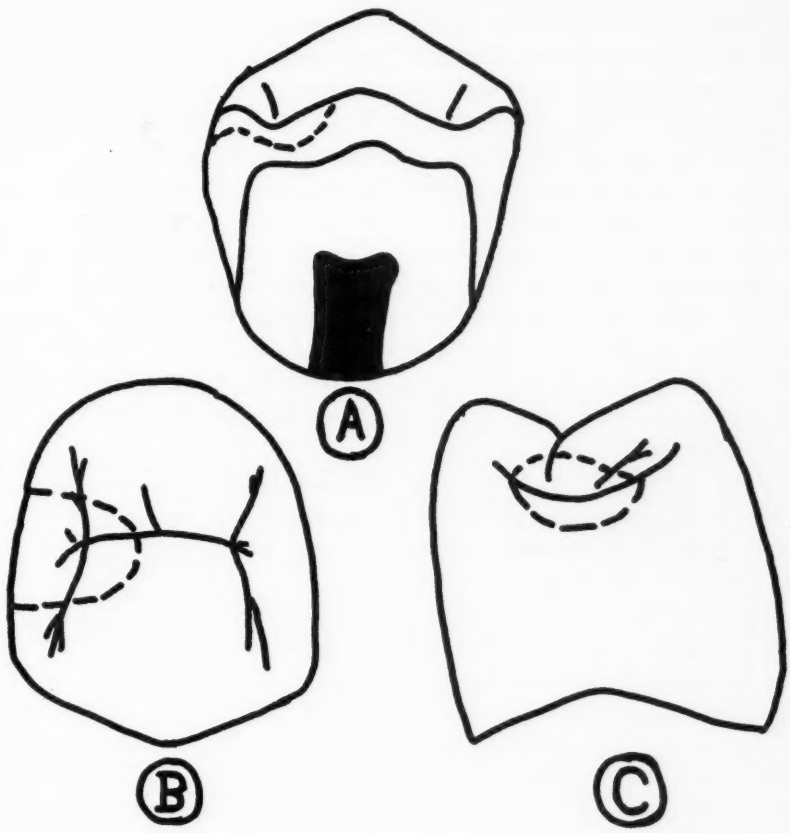


Fig. 3.—Occlusal rest preparation. *A*, Buccal view in mesiodistal section demonstrating the proximity of the rest preparation to dentine. *B*, Occlusal view. *C*, Distal view.

leverage, and the seating leverage afforded by indirect retention is less. It is for this reason, perhaps, that most rest areas are placed at the distal end of abutment teeth with distal-extension partial dentures. Osborne, Brills, and Lammie[3] point out that a more favorable distribution of occlusal forces can be obtained between abutment teeth and the distal-extension base by placing a rest on the mesial part of the abutment tooth and using flexible clasp arms. This places more load on the mucosa and alters the direction of rotatory movement on the abutment tooth.

THE OCCLUSAL REST AREA

The occlusal rest area is classically designed for use in sound enamel on posterior teeth. It is best prepared with round diamond stones comparable in size to a No. 6 and a No. 4 bur (Fig. 3).[9]

The larger stone is used to prepare a generalized outline form similar to that of a spoon, ensuring that the marginal ridge is reduced to give adequate clearance (1.0 mm. or more) for the rest when the opposing teeth are in occlusion. The clearance must leave an adequate thickness of the rest metal to prevent fatigue and future breakage at the point where the rest crosses the marginal ridge. If a sufficient amount of clearance cannot be obtained before cutting through the enamel, additional space may be gained by removing part of the enamel from the opposing cusp tip. The buccolingual width of the rest area should be one-half the distance between the buccal and lingual angles of the proximal surface used for the rest.[8] This width ensures adequate strength and food deflection by the rest. Generally, the rest area will be 2.0 to 2.5 mm. in diameter.[6]

The smaller diamond stone is used to deepen the central portion of the rest area so that the rest will be at an angle of less than 90 degrees to the minor connector.[9] This ensures that occlusal forces will be transmitted along the long axis of the abutment tooth with the least interference from the occlusion of opposing teeth. All sharp angles in the finished preparation of the rest area must be rounded, especially at the proximal edge. A sharp angle here will result in a fracture line in the completed rest.[8-10]

After the rest area is completed and all sharp angles removed, the surface of enamel must be smoothed and polished. Sandpaper disks mounted back-to-back can be used to smooth the preparation. Final polishing with pumice and whiting or a rubber pumice wheel is adequate.[8]

If a fissure exists beyond the depth of the prepared rest area, it may be filled with silver amalgam carved flush with the rest area surface and polished.[8]

Some authors advocate the use of silver nitrate as a sclerosing agent[6,8] if dentine is inadvertently exposed in the preparation of the rest area. The patient should be advised of this condition and of his responsiblity to keep such an area scrupulously clean after each meal in order to prevent caries in the exposed dentinal tubules. Actually, any patient should be thus forewarned about rest areas prepared in enamel.

When occlusal rest areas are placed in silver amalgam restorations to satisfy the patient's economic means, the rest area is prepared wider and more spoon-shaped than described above.[6]

When inlay or crown restorations are to be the site of rest areas, the rest area is carved into the wax pattern before casting to ensure an adequate thickness of gold.[9,10] The occlusal rest area may be shaped as outlined above, or modifications may be instituted.

INCISAL REST AREAS

The typical rest area prepared on an anterior tooth is made on a proximoincisal angle (Fig. 4). Usually a rest area prepared with diamond wheels in

enamel to a depth of 1,0 mm. and 1.0 to 1.5 mm. in width is sufficient.[6] Again, all sharp angles should be rounded and the surface polished smooth. Terzano[13] rounds the preparation by slanting the floor of the rest area buccally and lingually. The rest will form a hood, which gives greater stability.

McCracken[9] describes two other anterior rest areas that may be prepared in sound enamel. The first is a lingual rest on cuspids with a shallow lingual slope (Fig. 5). Diamond stones are used to lower the proximal ridge, with a deeper portion in the cingulum. Care must be taken to visualize the path of insertion when preparing this type of rest; it is not prepared perpendicular to the lingual surface of the tooth. A lingual panhandle inlay may be used for this type of rest area when insufficient thickness of enamel is present.[11] A rest such as this directs the occlusal forces low on the crown of the tooth and toward the center of the root mass.

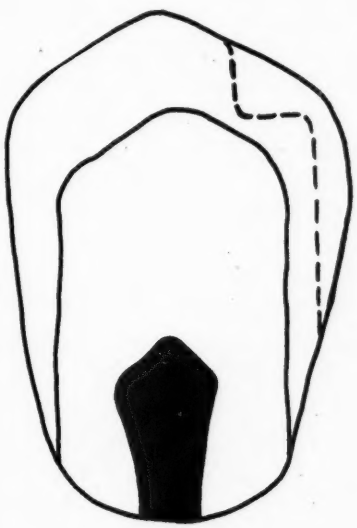


Fig. 4

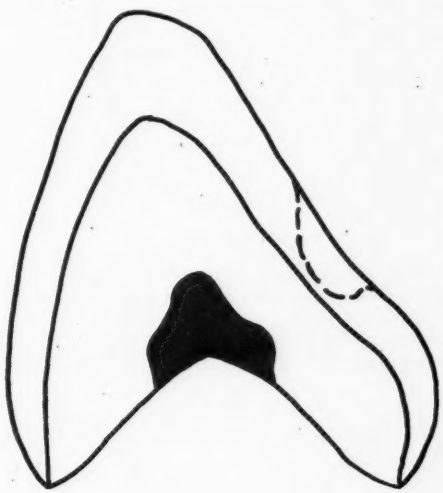


Fig. 5

Fig. 4.—A typical incisal rest area preparation shown in cross section on a lower canine tooth. The distal surface has been disked parallel with the path of insertion.

Fig. 5.—A cross sectional view of a lingual rest area prepared in enamel. Note the small amount of enamel remaining at the depth of the rest area.

The second anterior rest area that may be prepared in sound enamel is a mesio-incisal-angle notch which is approached across the lingual surface of the tooth by a rigid reciprocal clasp arm (Fig. 6).[9] McCracken describes the advantages of this type of preparation as follows: "definite support, little loss of tooth structure, and very little display of metal."

Another form of incisal rest that can be prepared in enamel has been described by Seiden[6] (Fig. 7). Both proximoincisal angles of the tooth are sliced at an angle 20 degrees to the long axis of the tooth. A rigid lingual arm for a reciprocally acting labial clasp arm then lays on the lingual surface of the abutment tooth and rests against the facets.

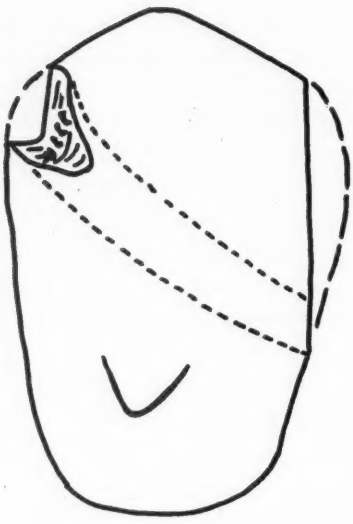


Fig. 6

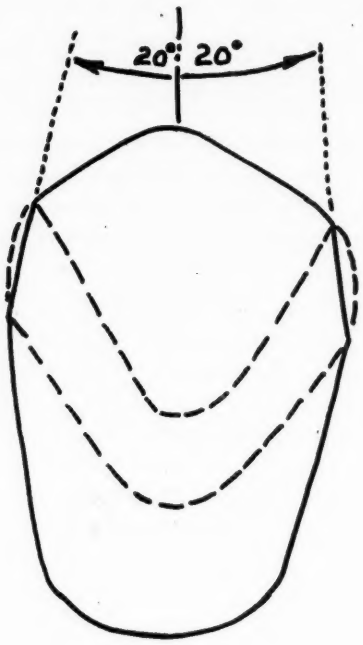


Fig. 7

Fig. 6.—McCracken's mesioincisal-angle rest area with a rigid lingual clasp arm. The dotted outline shows the tooth outline before preparation and the clasp arm outline. Note the rounding of the mesial rest area onto the lingual surface.

Fig. 7.—Seiden's incisal-angle rest areas sliced 20 degrees to the long axis of the tooth. The dotted outline of the rigid lingual clasp arm shows a minimum of metal on the labial surface.

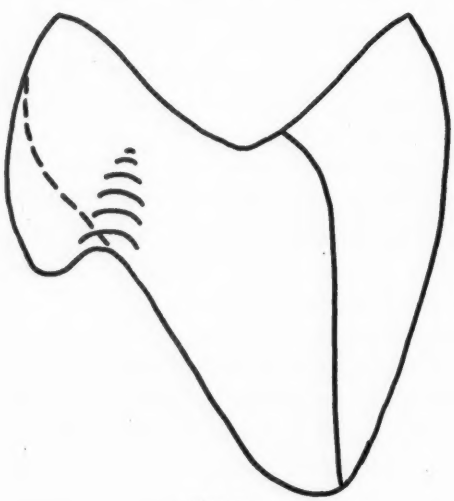


Fig. 8

Fig. 9

Fig. 8.—An overcontoured cingulum on a three-quarter crown restoration. The dotted line indicates the original lingual outline.

Fig. 9.—A circumferential lingual ledge rest area can be placed on posterior crown restorations. The dotted line outlines the rigid lingual clasp arm. The shaded area is an occlusal rest.

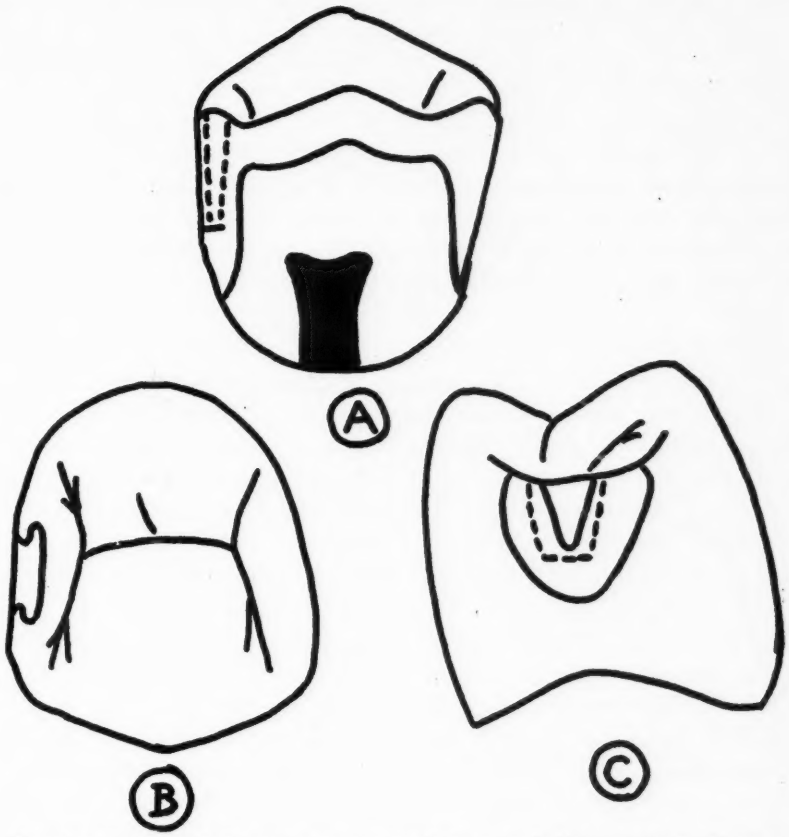


Fig. 10.—A tapered box-lock rest area prepared in a posterior crown. *A*, Cross section of buccal view. *B*, Occlusal view. *C*, Distal view. Note the slice of the distal surface parallel with the path of insertion.

Fig. 11.—A hook-type rest area near the gingival third on an anterior three-quarter crown.

REST AREAS ON METAL RESTORATIONS

Rest areas on metal restorations may be prepared in the wax pattern in the same shape and position as those described previously for preparations in sound enamel. However, many modifications of the rest area can be made if the basic functions of the rest are followed without violating physiologic limitations of the periodontium. Most modifications fall under the classification of precision rests, which have been described with various procedures for their fabrication and use in articles covering fixed-removable partial denture prostheses. This article will describe a few of the less complicated rest area modifications prepared in metallic restorations.

Anterior three-quarter crowns and full crowns may be overcontoured in the cingulum area to provide a cradle rest for a rigid lingual arm of a clasp (Fig. 8).[5,6,9] This rest area may also be used for an indirect retainer.

The rigid lingual arm of a clasp may be used with a circumferential ledge on the lingual side of posterior crowns.[9] It will supplement the occlusal rest with a lingual rest and minimize the amount of the lingual clasp arm exposed to the patient's tongue (Fig. 9).

When there is sufficient thickness on the proximal surface of a posterior crown preparation, a tapering box-lock rest area may be utilized (Fig. 10).[6] A tapered-fissure bur in a surveyor jig is used to prepare the rest area parallel to the path of insertion. All that is needed for retention with this rest area is a lingual clasp arm. Because of the rigidity afforded this type of rest, lateral forces are transmitted fully to the abutment tooth, and therefore it should be used only in young patients with slight occlusal force. As stated previously, the best guide to occlusal force is the patient's oral musculature and to a lesser degree the attrition exhibited by the remaining teeth.

Seiden[6] describes a hook-type rest area, for use with a minimal thickness of gold, that can be placed anywhere on a cast three-quarter crown or full crown. The most favorable position is close to the gingival third, to reduce leverage and to allow inconspicuous placement of facial clasp arms (Fig. 11). This type of rest would also be better if used for the young patient with light to medium occlusal force, since it has a lateral locking action.

Another ledge-type of rest area, taken from an unknown reference source, is reported to give satisfactory results. The ledge is placed in the gingival third on posterior crown restorations and allows a slight amount of lateral movement without undue force on the abutment tooth (Fig. 12). This rest does not require any relief of the opposing occlusion to obtain sufficient rest thickness, and it allows the artificial teeth of the appliance to contact the abutment tooth directly. A disadvantage which might occur with it would be the packing of food debris into the area between the abutment and the appliance lacking the protecting contours of an occlusal rest.

When a tooth is in infraclusion or is tipped out of satisfactory occlusion with the opposing arch, the occlusal rest can be used to correct the situation.[6] No rest area is prepared. The occlusal rest covers the entire occlusal surface of the tooth and is carved to be functional anatomically for mastication. Except when the

patient's economic limitations require it, this rest is never placed against an enamel tooth surface. Restoring the tooth satisfactorily beneath an already established rest is an extremely difficult procedure.

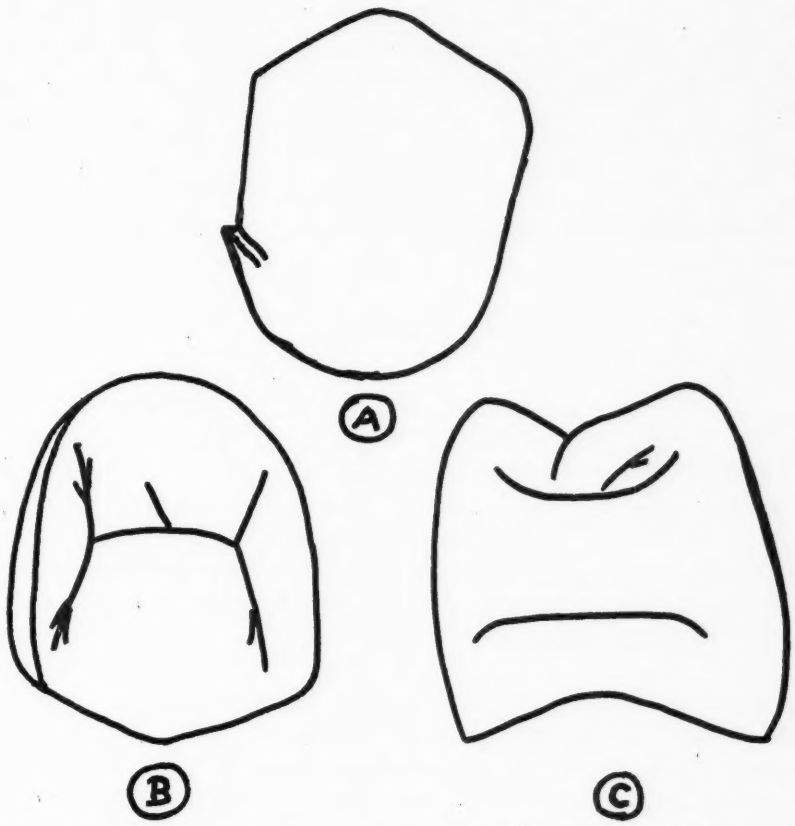


Fig. 12.—A ledge-type rest area on the distal end of a posterior crown restoration. It is placed in the gingival third. *A*, Buccal view. *B*, Occlusal view. *C*, Distal view.

SUMMARY

Any removable partial denture prosthesis requires rests which must seat and act in rest areas prepared for them within the physiologic tolerance of the periodontal membrane supporting the teeth involved. Several methods for the preparation of nonprecision rest areas for use in abutment teeth and for indirect retention have been described.

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FIXED PARTIAL DENTURES

ORAL REHABILITATION

Part I. Use of the P-M Instrument in Treatment Planning and in Restoring the Lower Posterior Teeth

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BOTH FUNCTION AND HEALTH can be restored to badly deteriorated, diseased mouths by utilizing modern techniques of oral rehabilitation. In times past, some of these "dental cripples" were condemned to full-mouth extraction and complete dentures because the success of rehabilitation procedures was dubious. Recent advances in dental technology, materials, and equipment, however, have simplified the task of rebuilding, restoring, and rehabilitating diseased mouths. This has enabled dentists to preserve many teeth which heretofore would have been sacrificed.

Optimum oral health should be the prime objective of *all* rehabilitation procedures, because the ultimate goal will always be to restore the mouth to health and preserve this status throughout the life of a patient. This article will describe one method to achieve this goal.

BASIC THEORIES, PRINCIPLES, AND CONCEPTS

A survey of the literature reveals a wide variety of methods, techniques, and instruments which were developed in attempts to solve the manifold problems of oral rehabilitation. The limitations of time and space restrict this discussion to the material which is pertinent to the technique to be described.

The Spherical Theory of Occlusion.—During the latter part of the nineteenth century, Bonwill and Von Spee described basic concepts in their classic papers. Bonwill[1] stated that if jaw development was ideal, an equilateral triangle would be formed by straight lines drawn connecting the centers of both condyles and connecting these centers and a point at the mesioincisal angle of the lower central incisors. Von Spee[2] stated that the points on the lower jaw teeth which move in contact with those in the skull lie on the surface of a sphere.

Read before the American Denture Society, Chicago, Ill., and the American Academy of Restorative Dentistry, Chicago, Ill.

Monson[3] suggested that, although theoretically the Bonwill triangle was equilateral, ideal conditions seldom prevailed and that usually an isosceles triangle resulted, with the short side between the condyle centers. He further stated that the center of a sphere with a radius of approximately 4 inches is equidistant from the occlusal surfaces of the teeth and the center of the condyles and that lines drawn from the center of this sphere must pass through the long axis of each tooth.

This "spherical theory" has been modified and further interpreted by Morton,[4] Maxwell,[5] and others. Although Monson's principles apply in ideal conditions, the latter, again, are seldom found in the adult dentitions which are to be rebuilt. Growth and development and environmental factors (i.e., the physiologic condition of the dental structure) have caused a deviation from the "ideal" because of loss of teeth, malposed and malaligned teeth, periodontal disease, altered muscular function, habit patterns, etc. D'Amico[6] has discussed the function of the cuspid teeth, and Meyer[7] and Brenner[8] have described a "wax chew-in" for reproducing the effects of eccentric functional movements in complete denture construction.

These principles and concepts form the basis for the technique of oral rehabilitation to be described in these articles on the rehabilitation of the upper cuspids, bicuspids, and molars. The upper cuspids will act as occlusal and incisal guides to the vertical dimension and centric and eccentric relations.

PRELIMINARY PROCEDURES

Every effort is made to secure a balanced occlusion of the remaining teeth. Schuyler,[9] Westbrook,[10] Brown,[11] and others have described both the importance of, and detailed techniques for, effecting occlusal equilibration. Questionable teeth should either be returned to optimum health by periodontic or endodontic procedures or be extracted. In no instance should the dentist proceed with rehabilitation until these preliminary steps have been taken. Only then can the treatment be planned.

EXAMINATION, DIAGNOSIS, TREATMENT PLANNING, AND PROGNOSIS

The importance of preliminary evaluation and planning of the over-all rehabilitation cannot be overemphasized.

Full-mouth roentgenograms and study casts are examined and the treatment is planned tentatively, with the calculated risks carefully evaluated. When the dentist has decided on his plan of treatment, an additional set of upper and lower *plaster* study casts are made for mounting on the instrument.

THE P-M INSTRUMENT

The purposes of the P-M instrument are (1) to engineer the entire oral rehabilitation before a single tooth preparation is made, (2) to determine the occlusal plane on the lower cast, (3) to study and plan the preparations of lower and upper teeth, (4) to orient the relationship of both arches in centric position with maximum esthetics and conservation of tooth structure, (5) to allow preparation plane guides to be made and buccal contours to be waxed on the teeth of the

mounted study casts exactly as they will be in the finished restorations, (6) to establish and carve the occlusal plane and curvature in the wax patterns, and (7) to check the finished restorations.

The P-M instrument consists of a main base to which is attached an upright or vertical rod and a platform base used to hold the lower cast (Fig. 1). Two assemblies are keyed to slide up and down the upright rod, with setscrews to

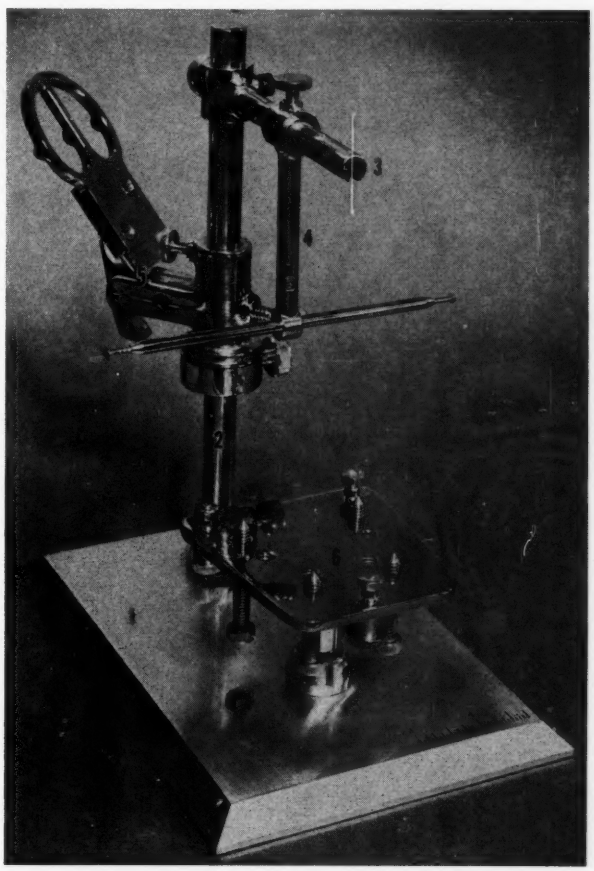

Fig. 1.—The P-M instrument consists of a main base *(1)* from which extends an upright rod *(2)* holding two assemblies. The first consists of a horizontal rod *(3)* and face-bow frame *(4)* attached to a collar and setscrew which allow the horizontal rod to slide up and down the upright rod and be locked into position. The face-bow frame is attached by a collar and slides out and back on the horizontal rod. It is composed of a vertical rod and a horizontal tube making a "tee" which has adjustable calibrated end rods that can be adjusted evenly out to meet the ends of the P-M face-bow rods. The second assembly is the upper cast mounting assembly *(5)* which consists of a lower collar and an upper collar having a hinged top. A webbed top is fixed to the hinged top to allow the upper cast to be mounted, articulated, opened, or swung out of the way. A platform base *(6)* is in front of the upright rod and attached to the main base by an upright.

Note the three hexagon nuts threaded on thumbscrews which are set through the bottom of the front and both back corners of the platform base. These are used to secure the cast to the platform base. Note also that four jackscrews are positioned to support the lower cast at the corners so that that the cast may be adjusted up or down easily. Note the scale at the left front of the main base and the divider seat at the left front corner to allow for measuring the divider opening.

lock them in position. A horizontal rod has two seats for dividers on the top and a keyway slot on its under side. A face-bow frame (Figs. 1, 2, and 3) is keyed to this rod and can be locked into either an anterior or posterior position to conform to either the anterior or posterior divider seat, depending on which one is used. Calibrated rods at the ends of the horizontal tube of the face-bow frame can be adjusted to meet evenly the ends of the P-M face-bow rods (Figs. 1, 2, and 3). After using the face-bow frame, it may be stored on a stud provided on the main base (see Fig. 6).

The upper-cast mounting assembly (see Fig. 6) consists of a base collar which is locked into position when the upper collar is mounted. The upper collar assembly seats on the lower collar and can either function laterally or be locked in centric position by a setscrew-key seating in the keyway on the front of the upright rod and a setscrew at the back. A hinged mechanism allows the upper cast to be raised or lowered.

Auxiliary parts of the instruments (Fig. 2) are the face-bow frame, the P-M face-bow with locking wrench, an Allen wrench to lock the upright rod in position, and two sets of dividers—one for diagnosis and the other, with the straight end sharpened, to facilitate cutting away excess plaster or wax.

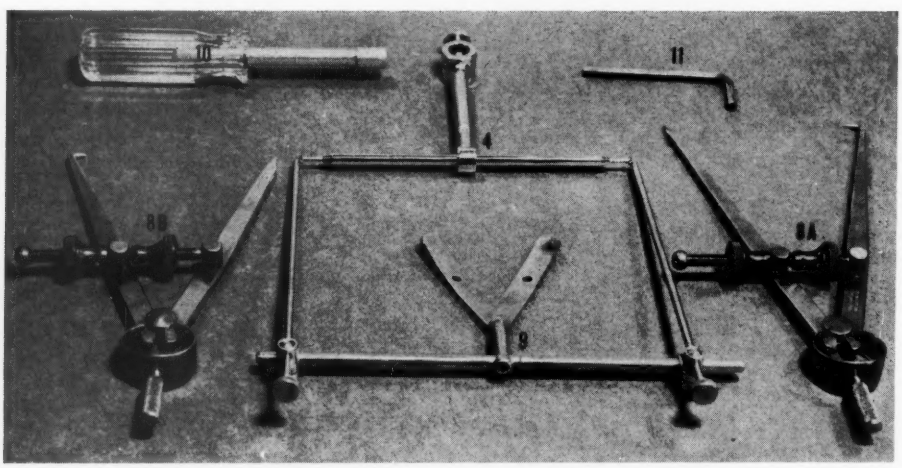

Fig. 2.—Auxiliary parts of the P-M instrument. The face-bow frame *(4)* has been removed from the instrument and the calibrated rods adjusted evenly to meet the ends of the rods of the P-M face-bow. The face-bow frame consists of a collar and setscrew keyed to a keyway on the underside of the horizontal rod. A horizontal tube and a vertical rod form a "tee" which is attached to the collar. Calibrated pins extend outward from the ends of the horizontal tube. Thereby the pins in the end of the horizontal tube can be adjusted evenly to meet the ends of the P-M face-bow rods. This is accomplished before the face-bow frame is seated into position on the horizontal rod of the instrument.

The P-M face-bow *(9)* consists of a bite fork joined to a crossbar and two face-bow rods attached to the crossbar. A screwdriver wrench *(10)* is provided to tighten the two nuts locking this assembly in position. An Allen wrench *(11)* is provided to lock the setscrews on the horizontal rod and the upper cast mounting assembly.

Two sets of dividers are provided. One is a pair of *diagnostic* dividers *(8A)* with a hooked end to seat in the divider seat on the tip of the horizontal rod (Fig. 1, *3*) and a straight end to sweep the diagnostic cast. The cutting dividers *(8B)* are modified so that the straight end has a sharp cutting edge to facilitate the removal of plaster or wax. Note that setscrews are provided to lock both dividers securely once they are set.

The P-M face-bow differs in design and usage from the conventional face-bow (a caliper-like device which is used to record the relationship of the jaws to the temporomandibular joints and to orient the casts in this same relationship to the opening axis of the articulator) as follows:

1. Although the P-M face-bow rod ends are adjusted to fixed, arbitrary anatomic landmarks on the face similarly to the conventional face-bow, *the wax index registration must be made at terminal hinge position* with a good imprint

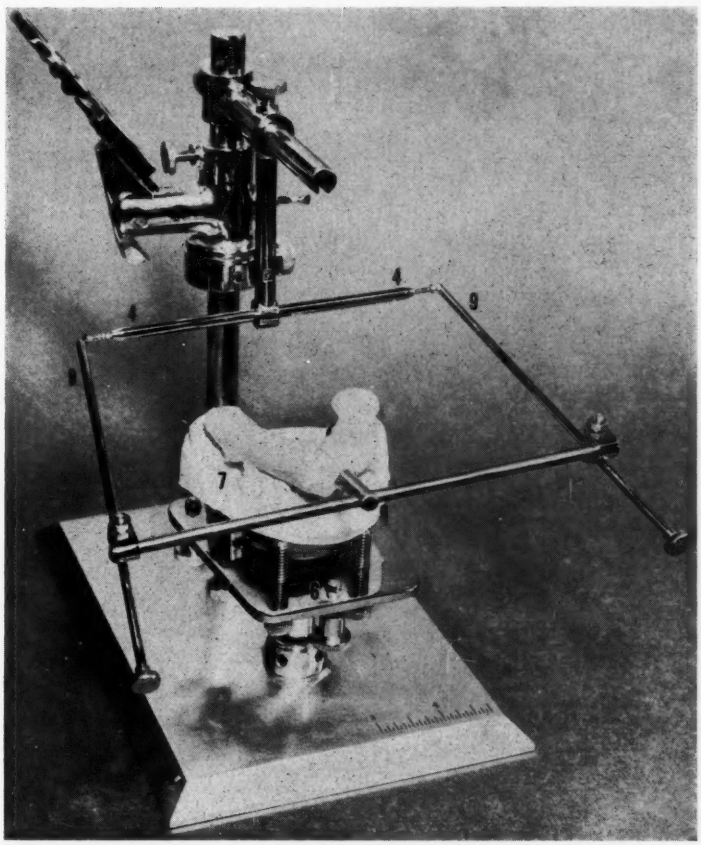

Fig. 3.—The P-M face-bow *(9)* is seated in position on the lower plaster cast *(7)* with the ends of the face-bow rods *(9)* approximating the pins in the ends of the horizontal tube of the face-bow frame *(4)*. Note how the jackscrews support the cast on the platform base *(6)*, enabling each corner of the cast to be raised or lowered to facilitate adjustment. Note also the Moldine in the center of the platform base to facilitate the preliminary cast adjustment.

of the *lower teeth*. This is different from the usual, arbitrary face-bow. Imprints of *upper teeth* are important in conventional face-bow usage, and the position of the mandible to the wax index is *not* important.

2. The P-M face-bow is adjusted to a point 12 mm. anterior to the tragus of the ear on the ala-tragus line (Camper's line), whereas conventional face-bows are adjusted either to other arbitrary anatomic landmarks or points located on the face coinciding with the hinge axis.

3. The P-M face-bow is used to mount the *lower cast,* whereas the conventional face-bow is used to mount the *upper cast.*

4. The P-M face-bow is adjusted to the P-M instrument in a different manner from that used with the conventional face-bow. The ends of the face-bow rods of the conventional face-bow are *always* adjusted to the ends of the condylar rods of an articulator. In contrast to this, the ends of the rods of the P-M face-bow *may be above or below* the tube ends of the face-bow frame *in the horizontal plane,* but must be even with them *in the vertical plane.* In other words, the P-M face-bow rods may be up or down from the ends of the face-bow frame when viewed from the front of the instrument, but must be even with them when viewed from above. The amount of deviation will depend upon the amount of deviation from the normal line and plane of occlusion of the case under consideration. When teeth are missing or malposed, the desired mounting is always the best compromise possible; this may not necessarily coincide exactly with the anatomic landmarks. In every case, however, the two P-M face-bow rod ends are in the same vertical plane as the ends of the face-bow frame.

ORAL REHABILITATION USING THE P-M INSTRUMENT

Mounting the Lower Plaster Study Cast.—Upper and lower plaster study casts are made. A P-M face-bow registration is made with the mandible in its terminal hinge position. Accurate wax imprints of the *lower teeth* are essential. The prepared wax clutch on the bite fork is held in position by the teeth. The P-M face-bow rods are adjusted to points on the face 12 mm. anterior to the tragus of the ear on the ala-tragus line (Camper's line).

Three brass hexagon nuts are seated on the collars engaging the set-screws at the front and at each back corner of the platform base (Fig. 1) preliminary to mounting the casts. A "ball" of Moldine is placed in the center of the platform base to facilitate the preliminary cast adjustment. The calibrated adjustable rods at the ends of the face-bow frame are moved out evenly to meet the ends of the rods of the P-M face-bow (Figs. 2 and 3). The face-bow frame is then locked into position on the horizontal rod, and the cast, seated into the wax index of the P-M face-bow, is placed ½ inch above the platform base with the P-M face-bow rods meeting the ends of the face-bow frame. Four holes (one at each corner of the cast as it is positioned) are selected, and jackscrews are threaded through the holes from the bottom. The cast is then seated on the Moldine and the P-M face-bow is seated on the cast and adjusted so the ends of the P-M face-bow rods touch the ends of the "tee" of the face-bow frame (Fig. 3). The P-M face-bow is then removed, and the dividers are adjusted to a selected distance (usually 4 inches) between their terminal ends. It is sometimes advantageous to shorten the radius of the sphere to 3½ inches or 3¾ inches in very small, steep arches or to lengthen the radius up to 4½ inches in very large, flat arches.

The hooked end of the dividers is next seated in the selected divider seat at the top of the upright rod. (If the posterior seat is used, slide a short length of rubber tubing over the anterior seat to prevent its being used by mistake.)

The horizontal rod is then raised or lowered to allow the straight end of the dividers to sweep over the occlusal plane of the cast from the distoincisal edge

of the cuspid to the last molar, describing a segment of the arc of an 8-inch or other selected sphere passing through the tips of the major cusps[5] and the center of the condyle (in ideal conditions) as described by Monson[3] (Fig. 4).

Establishment of this functional occlusal plane of the lower posterior teeth is perhaps the most important decision to be made in making the diagnosis for each patient. The cast is positioned on the Moldine, and the final adjustments are made by raising or lowering the jackscrews. By alternately using dividers (Fig. 4) and the P-M face-bow (Fig. 3), a compromise between the two allows the dentist

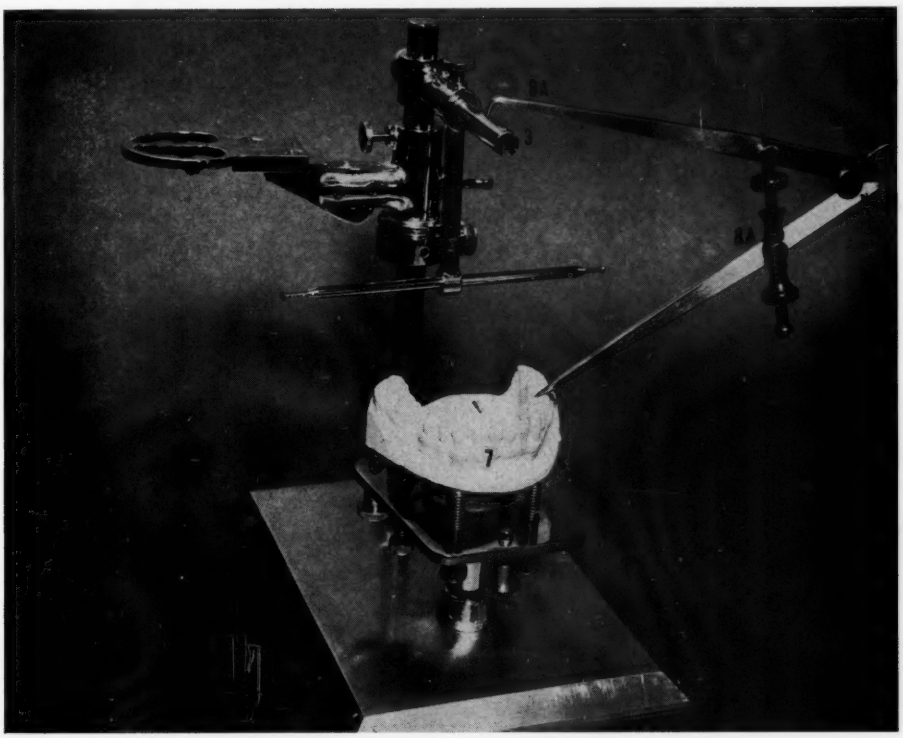

Fig. 4.—The cast *(7)* is in the same position as in Fig. 3. Note that the hooked end of the dividers *(8A)* is placed in position in the divider seat on the horizontal rod *(3)* and the straight end describes an arc of a sphere, establishing the occlusal plane (curvature).

to determine the *best possible occlusal plane.* Every factor must be taken into consideration as the *blueprint* for oral rehabilitation is established here. Roentgenograms must be examined to determine the amount of tooth structure which can be removed safely from both upper and lower teeth. If any teeth project dangerously past the selected line of occlusion, a compromise is necessary—either raising or lowering this plane. This may involve endodontic treatment or removal of the teeth involved.

After weighing all factors and positioning the lower cast in the optimum position, the cast is luted to the platform base with plaster or Hydrocal (Fig. 5). The face-bow frame is removed and stored on the stud on the main base (Fig. 6).

Mounting the Upper Cast.—The upper cast is placed in centric occlusion with the lower cast. (Wax interocclusal records must be used if insufficient teeth are present.) The upper-cast mounting assembly is positioned so that the webbed top is ¼ inch above the upper cast when in the *down* position. The setscrews are locked, and the cast is attached to the webbed top with plaster (Fig. 6). Thus the study casts are mounted to reproduce the best possible functional occlusal plane.

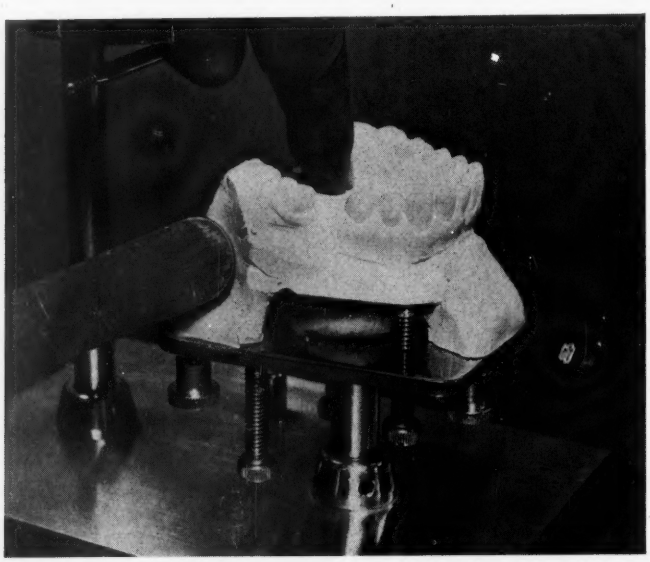

Fig. 5.—After establishing the most ideal functional occlusal plane possible by means of both the dividers and the face-bow, the cast is luted in position with plaster engaging the hexagon nuts at the front and both back corners.

Cutting the Lower Cast to the Occlusal Plane.—The upper-cast mounting assembly is first swung laterally out of the way. The cutting dividers are then seated in the selected divider seat and the cutting ends are swept back and forth over the occlusal surface of the posterior teeth, removing all plaster *above* the occlusal plane. The cusps of some teeth will be found to be below this *established functional occlusal plane,* while those cut down will exhibit a curved plane. (Fig. 7.)

Cutting the Lower Cast to the Preparation Plane.—Open the cutting dividers 1/16 inch more than the previous setting and sweep back and forth, removing additional plaster to allow for adequate thickness of gold in the finished castings. In practice, it has been found desirable to remove this 1/16 inch of plaster in several graded sweeps rather than to attempt to remove all of the desired amount of plaster at once. The *preparation plane* has now been established, passing through the tips of the major cusps. It is sometimes possible to balance the tip of the buccal cusp of the lower first bicuspid to the occlusal plane so that it does not have to be restored in gold; this provides a much more esthetic result. (Fig. 7.)

Constructing the Preparation Guides.—A ¼-inch thickness of autopolymer resin is pressed onto the buccal and lingual surfaces of the lower cast from the cuspid

back to the distal end of the last molar and from the mucobuccal fold to within 3 mm. of the established preparation plane and allowed to set. (A buccal and lingual guide is made for each side.) Modeling compound is added over the top of the acrylic resin guides with an excess extending above the preparation plane. The modeling compound is then removed down to the *preparation plane* with the cutting dividers. (Fig. 7.)

PREPARATION OF LOWER POSTERIOR TEETH IN THE MOUTH

Marking the Established Preparation Plane Guide on the Teeth.—Each preparation plane guide is seated in the mouth, and a pencil line is drawn on the buccal and lingual surfaces of the teeth at the junction of the top of the guide.

This is done by holding the guide in place with one hand while drawing the pencil line with the other. This procedure is repeated using each of the four

Fig. 6.—The Allen setscrew on the collar of the horizontal rod (Fig. 4, *3*), is locked tightly, and the face-bow frame *(4)* is removed from the horizontal rod and secured to its storage post on the base. The upper cast mounting assembly *(5)* is then swung into position. It consists of a lower collar to lock the assembly in position. The upper collar assembly seats on the lower collar and can either function laterally or be locked in centric position by a setscrew—key seating in the keyway on the front of the upright rod *(2)* and a setscrew at the back. A hinged mechanism allows the upper cast to be raised or lowered.

The upper cast is placed in centric occlusion on the lower cast. Wax interocclusal records may be used if necessary. The upper cast mounting assembly *(5)* is adjusted so that the webbed top is ¼ inch above the top of the upper cast when it is in the "down" position. The cast is attached to the webbed top with plaster.

guides. After removing the guides, the dentist can look into the mouth and see how much of the tooth must be removed from the occlusal surfaces to bring the natural teeth down to the preparation plane established on the study cast. Tooth substance is then removed down to the pencil marks, and the guides are reseated to make sure that the correct amount of the tooth has been removed. (Fig. 8.)

Completing the Preparations.—At this stage, the preparation plane has been established for the *tips of the cusps only.* To complete the occlusal preparations, additional tooth substance must be removed in all directions from the cusp tips to allow for the inclined planes, depth of fossae, spillways, etc. (Fig. 8.)

To determine the cusp height and fossae depth for the individual patient, the original Hydrocal study casts are re-examined. An attempt is made to reproduce a similar occlusal pattern or one that is most favorable for the patient. At this time, the upper cusp inclines, especially the cuspid articulations, are re-examined to determine the best possible cusp-to-fossae pattern. The lingual slopes of the upper cuspids determine how much "cusp rise" will be possible in the finished

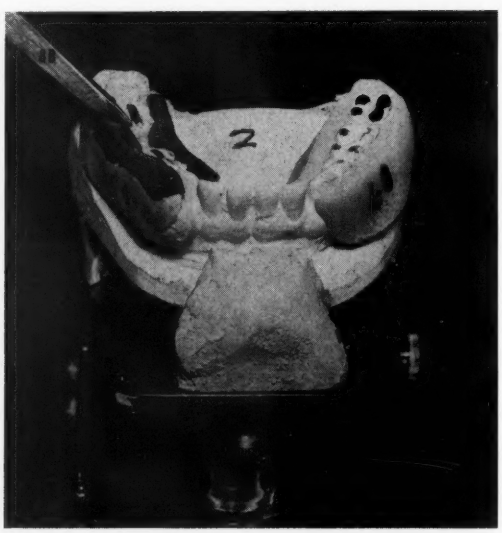

Fig. 7.—Making the preparation plane guides. Prior to forming the guides, the occlusal surfaces have been swept with the cutting dividers *(8B)* to remove plaster to the level of the preparation plane (curvature). Autopolymer resin cores are made to fit accurately against the buccal and lingual segment of the cast covering the posterior teeth and the mucosa down to the mucobuccal fold. The tops of these cores are approximately 3 mm. below the preparation plane *(LB).* Modeling compound is added to the tops of the acrylic resin *above* the preparation plane *(RB).* Dividers are used again to trim the excess modeling compound down to the preparation plane.

reconstruction. Since the upper cuspids will be the guides in eccentric functional movements, it is important to observe these prior to the preparation of the lower teeth.

The fossae, spillways, etc., must be reduced now to a depth which will allow for adequate bulk of gold in the finished castings in all areas of the functional occlusal surface of the teeth themselves (Fig. 8).

The axial surfaces of the preparations are completed according to the dentist's judgment, and a gingivectomy is performed if deemed advisable.

Obtaining Master Cast and Wax Interocclusal Records.—An impression is made to obtain a working or master cast with removable dies. We use the hydrocolloid technique[12] to accomplish this, but other materials may be used. Accurate interocclusal records are taken in Aluwax, with the mandible in its terminal hinge

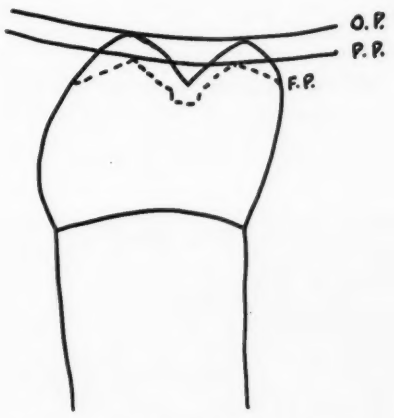

Fig. 8.—A diagram showing the amount of study cast and tooth substance to be removed. The occlusal plane *(O.P.)* is the plane passing through the tips of all major cusps of the lower posterior teeth. The dividers are swept in this plane first on the study cast. After the excess plaster (above the occlusal plane) has been removed, the dividers are opened an additional 1/16 inch and again swept back and forth over the study cast to establish the preparation plane *(P.P.)* The preparation plane insures adequate thickness of gold over the tips of all cusps. In the mouth, the preparation plane guides are used to facilitate tooth removal down to this plane. After this, additional tooth substance is removed to complete the occlusal preparations *(F.P.)*. The occlusal surfaces are thus reduced to allow for depths of the fossae, grooves, spillways, etc., resulting in a uniform thickness of gold over the entire occlusal surface of the finished castings.

position. These are chilled immediately, and *all excess wax is carved away, leaving only the indentations of the occlusal surfaces of the prepared teeth* on the lower side and the indentations of the tips of the cusps of the upper teeth on the upper side. These interocclusal records are checked back in the mouth for accuracy and immediately placed in water until they are used for mounting the upper cast.

P-M FACE-BOW REGISTRATION TO MOUNT THE LOWER WORKING CAST

A P-M face-bow registration is made in exactly the same manner as previously described for use in mounting the study cast. Care is taken to obtain a sharp imprint in the wax of *only the occlusal surfaces of the prepared lower teeth.* In no instance should the wax be allowed to flow down between the prepared teeth.

MOUNTING THE MASTER CAST

Use the identical procedures for mounting the working cast as were used for the study cast, with this exception: the diagnostic dividers are set at the original

opening for the occlusal plane, so that when the cast is correctly positioned the divider tip will sweep 1/16 inch *above the tips of the major cusps of the prepared teeth* (Fig. 9). This will allow for an even thickness of gold in the finished restorations. After being positioned correctly, the working cast is luted to the platform base with Hydrocal. Care is used to avoid covering the ends of the dowel pins (in the dies) of the prepared teeth with plaster, to facilitate the removal of the dies.

FABRICATING THE WAX PATTERNS AND FINISHING THE CASTINGS

Wax is applied to the preparations and the final carving done, leaving an excess of wax over the occlusal surfaces. The occlusal surfaces are refined one at a time, starting at the first bicuspid and working back to the last tooth. First,

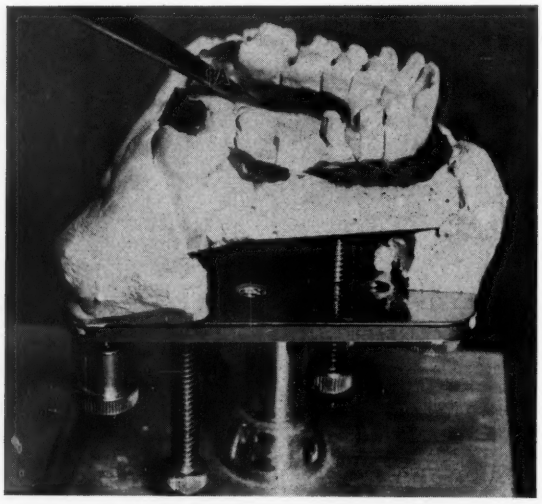

Fig. 9.—The master cast is mounted in the same manner as the study casts were mounted, *except* the diagnostic dividers *(8A)*, set at their original settings, now sweep 1/16 inch *above* tips of the cusps of the prepared teeth.

the excess wax is swept away down to the occlusal plane with the cutting dividers. The upper cast is then brought into occlusal contact, and the location of grooves, cusp tips, fossae, spillways, etc., are determined. At this time, the upper plaster cast may be carved down to conform to the functional anatomic construction carved into the lower wax patterns. To facilitate this, it is sometimes helpful to have the occlusal third of the teeth of the upper cast poured in a hard wax. The wax is easier to carve, and it prevents contamination of the wax patterns with plaster. The corrected upper cast can serve as a guide for cutting down the upper teeth to remove gross interferences when the lower castings are set.

The finished lower wax patterns must conform to the cuspal inclines selected and be in harmony with the cuspid articulation. As a final check, the diagnostic dividers are swept along the occlusal plane to make sure that the divider tips contact the tip of all major cusps.

The wax patterns are invested, cast, and finished. The finished gold castings are returned to the master cast. The dividers are used again to check their contacts with the tips of major cusps of the lower posterior castings.

COMPLETING REHABILITATION OF THE LOWER TEETH

When the patient returns, the temporary fillings are removed, the prepared teeth are cleaned, and the castings are seated. Their contact, contour, etc., are checked by roentgenograms to make sure that all castings are seated correctly.

The modified upper cast is now studied, to facilitate removal of gross interferences of the upper teeth. These premature contacts are cut away until the patient is comfortable and the desired vertical dimension is established. The dentist must be sure that *all* occlusal interferences are eliminated in centric relation and in the envelope of function on the working side and that the patient can *tap, tap, tap*[11] the teeth together without interference. Also, the dentist must make certain that interferences on the balancing side are eliminated. The balancing-side contacts should be freed so that a thickness of silk tabulator ribbon can be pulled through while the teeth are in contact on the working side.

CEMENTATION

Cementation is a very important step in the procedure. To reduce pain during cementation and postoperatively, the teeth are chilled by a modification of a method described by Ludwick.[13]

The prepared teeth are conditioned by lowering their surface temperature as rapidly as the patient can tolerate cold. Tap water is used initially, colder water being substituted as soon as possible. The water is held in contact with the prepared teeth and replaced as soon as it becomes warm. It seldom requires more than 2 minutes for this preliminary cooling procedure before the patient can tolerate cracked ice in direct contact with the prepared teeth. These teeth are packed in ice for 5 minutes just prior to cementation. Cube ice is reduced to a smaller size in a household ice crusher. A unilateral impression tray is used to hold the cracked ice in position on upper teeth.

The teeth are dried with cotton pellets, and calcium hydroxide is applied to the exposed dentin inside the margins of the prepared teeth. Final drying (with air used *sparingly*) is done just prior to cementation. The cement mix should be ready as soon as the teeth are dried, to gain full advantage of this cooling procedure. Caustic or irritating drugs such as phenol and alcohol are never used. This procedure produces two desirable results: anesthesia of the prepared teeth during cementation and elimination of the thermal shock caused by chemical action of the cement mix.

The addition of U.S.P. eugenol to the cement liquid, as described by Schorr,[14] assists in preventing pain. These procedures have eliminated the need for anesthesia to reduce pain during cementation for most patients. They allow patients to enjoy postoperative mouth comfort after even the most complicated cementation procedures.

SYNOPSIS OF THE COMPLETE TREATMENT PLAN*

The P-M instrument (Fig. 1) is used to establish the most ideal functional occlusal plane (or curvature) possible in rehabilitating the mandibular posterior teeth. This desired plane (or curvature) is first established on the lower study cast, and the diagnosis and treatment are planned (Figs. 3 to 7). The teeth are prepared (Fig. 8), the impressions are made, and the working cast is mounted in a similar manner (Fig. 9), so that the gold restorations of the lower posterior teeth can be finished on the instrument. These castings are set permanently, and occlusal interferences on the upper teeth are removed to make the patient comfortable and to establish the desired vertical dimension (Fig. 10).

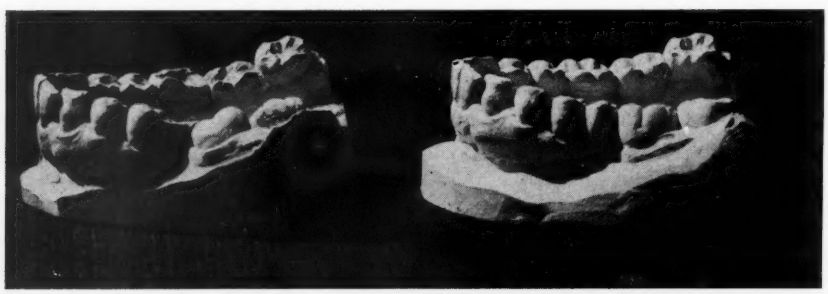

Fig. 10.—Casts before and after complete lower posterior rehabilitation. *B*, Before treatment there was a "swayback" functional occlusal curvature caused by a premature loss of the lower first molar and a perpetuation of the deformity in the original fixed partial denture. *A*, the optimal functional occlusal curvature has been established, and the deformity has been eliminated. Note the improved cusp-to-fossae patterns providing optimal functional efficiency. (The right third molar was disregarded because it was not in occlusion.)

The maxillary posterior teeth and *cuspids* are reconstructed *after* the lower restorations have been completed and set permanently.* The maxillary incisors may be rebuilt either before or after these other procedures are complete. Our usual practice is to defer making restorations on the maxillary incisors and mandibular cuspids until all other phases of the work have been completed. The maxillary cuspids function as "stops" to maintain the established vertical dimension of occlusion while the posterior teeth are being treated.

When the upper teeth have been prepared, a complete arch impression is made to obtain a master cast. Centric and protrusive interocclusal wax records and a conventional face-bow registration are obtained preparatory to mounting the upper cast on an adjustable articulator.† The cuspid restorations are made first. Both centric and eccentric relationships are reproduced as accurately as possible. These positional relationships are checked and corrected after the cuspid castings are seated in the mouth. It is important to note that these castings are *not* cemented in place at this time because they are to be returned to the master cast.

*The procedures for restoring the upper teeth are described in Part II of this series.
†Hanau Model H-2 with a P-R attachment.

After the desired centric and eccentric mandibular positions have been established with these cuspid castings in place, a functionally generated path record is made. This is done by having the restored mandibular teeth cut the wax and thus record both centric and eccentric tooth relations, with the two upper cuspids acting as bilateral incisal and occlusal guides for the human articulator.

Artificial stone is poured into the wax chew-in record, and this is mounted on an adjustable articulator with the condylar guides locked. Thus the articulator can function only as a hinge. The anatomic lower cast is mounted also on another mounting plate, so that the anatomic and composite casts are interchangeable. Castings are fabricated and corrected to the stone cast made from the wax chew-in record, and all castings are tried in the mouth. Minor final corrections to the posterior tooth occlusion are made with both cuspid castings (the bilateral occlusal-incisal guides) reseated in the mouth. All of the castings are then cemented with the same procedures used for cementing the lower restorations.

DISCUSSION

There are many advantages of effecting the rehabilitation of the lower posterior teeth, the upper posterior teeth (and cuspids), and the other anterior teeth in separate series of appointments. The work on the different segments can be completed more quickly and easily and with much more comfort for the patient. The dentist eliminates much of the time-consuming, difficult, and uncomfortable (for the patient) removal and reseating of temporary fillings. The total chair and laboratory time for the rehabilitation is significantly reduced. The patients appreciate anything which expedites having their work finished faster so that they can enjoy the oral health, comfort, functional efficiency, and esthetics which are the prime objectives of oral rehabilitation.

SUMMARY

1. The principles and concepts involved in oral rehabilitation using the P-M instrument have been discussed.

2. The technique for using the P-M instrument in establishing the functional occlusal plane of the lower posterior teeth for both study and working casts has been described.

3. A method of fabricating wax patterns for the finished castings has been outlined.

4. The advantages of this technique of oral rehabilitation have been discussed.

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ORAL REHABILITATION

Part II. Reconstruction of the Upper Teeth Using a Functionally Generated Path Technique

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THE PROCEDURES in diagnosis and analysis for complete rehabilitation and the techniques for rehabilitation of the lower posterior teeth using the P-M instrument to establish the functional plane of occlusion, cusp height, fossae depth, and incline angle have been described* (see Fig. 1). The lower reconstruction is completed, gross occlusal interferences with the upper teeth are removed, and the castings are permanently cemented in position. Rehabilitation of the upper teeth can be started, or it can be postponed until convenient. When the work on the lower and the upper arches is done separately, it is more comfortable for the patient and it is easier on the dentist and his staff. It also simplifies scheduling patients and laboratory procedures. Completing the work in one arch first minimizes chances for error and simplifies rehabilitation by eliminating many time-consuming procedures.

This article will describe a method of rehabilitating the upper teeth using a "functionally generated path" record based on a modification of the principles outlined by Meyer[1] and Brenner.[2]

THE IMPORTANCE OF CANINE FUNCTION

Brown,[3] Schuyler,[4] Westbrook,[5] and others believe the cuspid teeth to be important guides to eccentric movements.

D'Amico[6] states, "The canine teeth serve to guide the mandible during the eccentric movements when the opposing teeth come into functional contact. . . .The upper canine teeth, when in functional contact with the lower canines and first premolars, determine both lateral and protrusive movements of the mandible. . . .The canine teeth also have a unique function. They are extremely sensitive organs. When their opponents come in contact during attempted eccentric movements of the mandible, they transmit in a greater degree than any other teeth the desirable periodontal proprioceptor impulses to the muscles of mastication,

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Read before the American Denture Society, Chicago, Ill., and the American Academy of Restorative Dentistry, Chicago, Ill.

*Mann, A. W., and Pankey, L. D.: Oral Rehabilitation. Part I. Use of the P-M Instrument in Treatment Planning and in Restoring the Lower Posterior Teeth, J. PROS. DEN. 10:135-150, 1960.

reducing muscular tension and thereby reducing the magnitude of the applied force. This is the all important function we seek to reduce or prevent failure of restorations and the periodontium."

Brecker[7] states, ". . . registrations on the patient and transfers from the patient to any type of articulator cannot be made without errors. The more steps required in establishing and transferring the records, the greater is the chance for errors.

"The human jaw, with all its limitations, with all its interferences and with all its problems created by habit, makes the best articulator. Consideration should be given to the patient's individual pattern of chewing."

FUNCTION OF THE CUSPID TEETH

In studying the occlusion of patients, we occasionally find the cuspids in such excellent functional occlusion that they can be used "as is" and so do not have to be prepared. More frequently, however, these teeth must be reconstructed to provide the desired function. Occasionally, they are so far out of contact that a lingual cusp must be built up to allow optimal contact with the lower teeth. This "bicuspid" modification of the cuspid seems to function ideally, but care must be exercised to balance its contacts accurately for centric and lateral occlusion and incisal path guidance. Both upper cuspids must be in good functional occlusal contact in centric and eccentric positions before the posterior teeth are reconstructed. *It is essential that the cuspids on both sides contact simultaneously, firmly, and solidly without a slide. If this condition cannot be obtained with the upper cuspids as they are, it must be obtained by reconstruction of the cuspids to this ideal situation even though no caries exist.*

The cuspids, or their first bicuspid substitutes, then become bilateral incisal or occlusal guides which, with the temporomandibular joints, function as the "human articulator." Thus, an ideal functional pattern can be established to which all occlusal surfaces of the upper posterior teeth can be built.

Time and space do not permit a more thorough discussion of this subject. We suggest, however, that the monograph by D'Amico,[6] in which the function of the canine teeth is discussed in detail, be read.

There is a definite relationship between incisal guidance, condylar guidance, and Spee's curve. There tends to be a harmony of steepness or flatness which in turn determines the cusp height, fossae depth, and occlusal tooth form of the posterior teeth. During every phase of the rehabilitation procedures, from the initial study of the patient's casts through both the lower and upper procedures, the dentist must always utilize his knowledge of these factors in planning and carrying out his treatment procedures.

The upper incisors can be restored best after the upper cuspid restorations and the posterior reconstruction have been completed. By leaving the incisors unchanged, they become valuable guides to the vertical dimension during all stages of the posterior oral rehabilitation. The cuspids act as "incisal guide pins" to enable us to check on whether or not the vertical dimension is correct at each step of our treatment.

PREPARATION OF UPPER TEETH

All of the posterior teeth are prepared, and the cuspids also if they require it.* Have the patient "grit his back teeth together" on soft wax, and remove tooth substance until 1.0 mm. of wax is retained over the entire functioning surface of all prepared teeth. By exercising care in the preparation of the buccoclusal line angle, a minimum of gold will show. *However, be sure to remove enough tooth substance to clear the occlusion. In no instance should less than 1.0 mm. of space exist between upper and lower occlusal surfaces in both centric and eccentric excursions, with the exception of the tips of the buccal cusps of the bicuspids.* This can best be effected by using an inside bevel on the buccal cusps of the upper bicuspids and sometimes the first molars, to provide for esthetics in that a minimum of gold shows, yet provide enough bulk so that grinding will not penetrate the occlusal surfaces of the restorations when the occlusion in lateral movements is refined. Always "shoe" the lingual cusps of the preparations, using a contrabevel.

Pinledge inlays or three-quarter crowns on the cuspids and MOD onlays or three-quarter crowns on the posterior teeth are the preparations of choice. When extensive damage to teeth has occurred, full coverage may be necessary. However, this should not be used if a restoration that conserves more tooth structure can be employed.

UPPER MASTER CAST

Although we prefer to utilize the hydrocolloid technique to obtain a master cast of the entire upper arch, it may be obtained by other methods. However, this master cast must be made so that the die of each prepared tooth can be removed from the base and reseated exactly in its original position.

MOUNTING THE MASTER CAST

Preliminary to mounting the master cast, interocclusal records are made in both centric and protrusive jaw relations. A conventional face-bow transfer of the upper cast to an adjustable articulator is made.† The lower die stone anatomic cast, made from a hydrocolloid impression, is mounted with the centric relation record. *It is important to trim wax records so that they contact only the occlusal seats* (not the steps or interproximal surfaces) *of the prepared teeth and the tips of the cusps of the teeth in the adjacent arch.* It is also desirable to remove all of the dies except the most medial and most distal ones before seating the records preparatory to mounting the cast. This minimizes the chance for error. The condylar guides of the articulator are then adjusted to the protrusive records. The incisal guides are adjusted to the desired angle, previously determined from the diagnostic cast analysis.

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*Dentists who are inexperienced in rehabilitation work should restore the cuspids first, then prepare the posterior teeth after the cuspid restorations are finished and cemented. In these instances, all occlusal interferences on the posterior teeth in the centric and eccentric positions should be removed so that the cuspid occlusion can be perfected without interference.

†Hanau H-2 with a P-R attachment.

The angle of the cuspid incline was determined at the time the diagnostic casts were mounted and studied. When the lower wax patterns were carved, the angle of the carving, cusp heights, and fossae depths were made to harmonize with this angle (Fig. 1). The incisal guide-pin guidance of the articulator is set to enable the dentist to obtain this desired angle on the carvings of the cuspid wax patterns (Fig. 2). This has been described in detail by Swenson.[8]

THE "FUNCTIONALLY GENERATED PATH" TABLES

"Functionally generated path" tables (one for each side) are fabricated to support the wax generated path records.

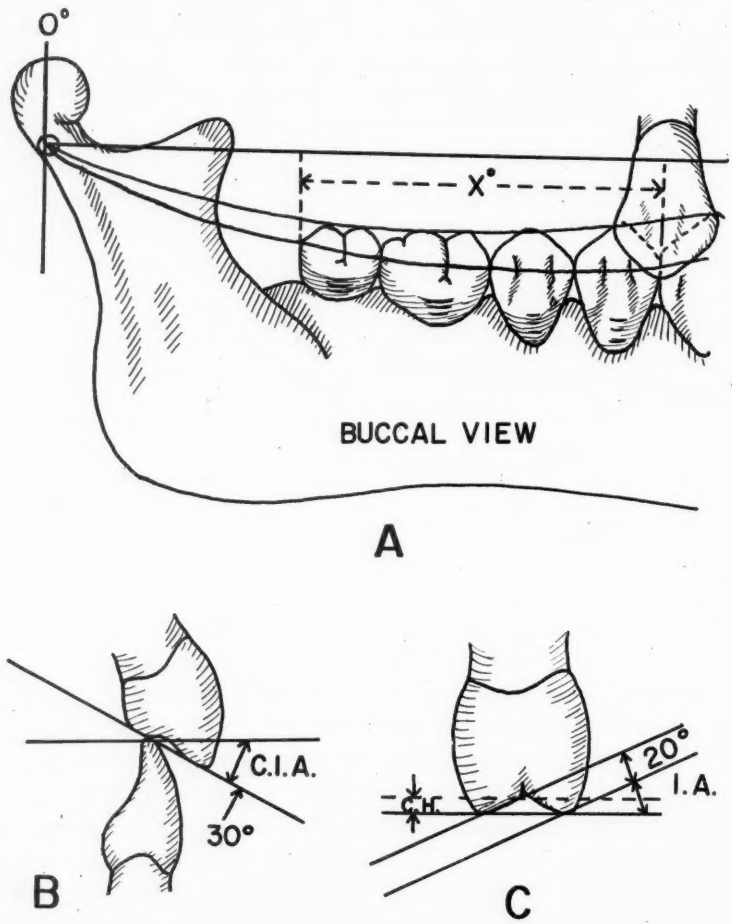

Fig. 1.—The relation between the condylar guidance, the incisal guidance (represented by the cuspids), and the Spee's curve on the working side where the condylar guidance is 0 degrees. *A*, The cusp height, fossa depth, and incline angle vary as follows: Since the working-side condyle guidance is 0 degrees and the incisal guidance is at a varied but known angle, the unknown (x degrees) cusp height, fossa depth, and incisal angle of each individual incline vary in relation to the distance from the cuspid occluding contact to the condyles and decrease posteriorly. *B*, Determination of the angle of the cuspid *(C.I.A.)*. *C*, Relation of the cusp height *(C.H.)*, fossa depth, and incline angle *(I.A.)* to the cuspid incline angle.

Wax patterns are made on the dies of the most mesial and most distal prepared teeth. The patterns are waxed short of the margins. A thin sheet of casting wax is then pressed so that it contacts *only the occlusal* surfaces of the other prepared teeth, with at least 0.5 mm. of space between it and the occlusal surfaces of the opposing lower teeth in all excursions. This sheet of wax should extend outward approximately one-half the width of the teeth, both buccally and lingually. It is then luted to the wax patterns on the terminal abutments. This wax should

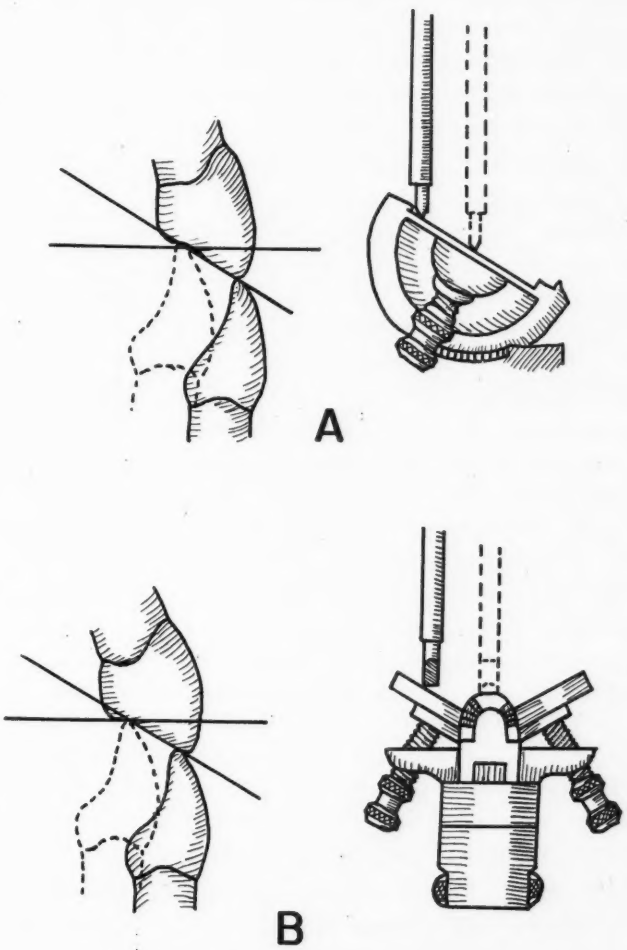

Fig. 2.—Centric position on the teeth and on the articulator are shown by dotted lines. *A*, The incisal guide table of the articulator is adjusted to an inclination in the protrusive position which is in harmony with the incisal guidance provided by the cuspids on the stone cast. *B*, The incisal guide table of the articulator is adjusted to the left lateral jaw relation. It is set in harmony with the cuspid relationship on the stone cast. The incisal guide table on the articulator functions to protect the stone cast and give the dentist a definite angle of incisal guidance which can be measured. The incline angle of the cuspid determines the articulator setting and guides the mandible when the occlusion is being perfected in the mouth. The degree of the condylar and incisal guidance decreases posteriorly from the incisal guide pin of the articulator through the teeth of the cast to the condylar guide adjustments.

be formed so that the critical parts of the stone die will be protected, because the finished wax patterns must be made later. Obviously, extreme caution should be used in seating these "tables" on the dies after casting.

The wax pattern is invested and cast in either gold, coin silver, or technique metal. It is carefully returned to the stone dies for checking to make sure ample clearance in all functional movements has been provided. The generated path tables should seat accurately both on the cast and in the mouth, yet, when a small bulk of wax is placed on them, the patient should be able to make the functionally generated path record without touching the metal at any place.

FABRICATING THE BILATERAL INCISAL OR OCCLUSAL GUIDES

Whenever possible the cuspids should be used as guides, although it is sometimes necessary to use the first bicuspids when the cuspids are missing or malposed. They should be carved to give what we call a "long centric" or "free centric" *occlusion.*

The length of the "long centric" or "free centric" occlusion is determined by the distance from terminal hinge centric relation and the normal freedom of movement in the envelope of function. This will vary greatly with individual patients. For example, the occlusions of patients with steep incisal and condylar guidances and with Spee's curves with short radii will be "locked in" and will have little "free centric" occlusion and a small envelope of motion in function. Patients with an edge-to-edge occlusion of the anterior teeth may have much greater freedom, much greater "long centric" occlusion, and a larger envelope of motion in function because their occlusions are not "locked in." They possess flatter condylar and incisal guidances and Spee's curves with long radii. Obviously, occlusal tooth forms must harmonize with these factors. We would expect higher cusps and deeper fossae in the teeth of patients with deep vertical overlaps and the reverse in the teeth of those with edge-to-edge relationship. (Fig. 3.)

The cuspid wax patterns and gold castings are fabricated and corrected to the centric position and eccentric movements, as close to the ideal as the articulator will permit.

These cuspid "guide" castings are ready to seat in the mouth and perfect occlusion before establishing the chew-in record.

FUNCTIONALLY GENERATED PATH TECHNIQUE*

This one step is undoubtedly the most important in the entire technique, for it is here that all centric and eccentric functional jaw relations are recorded. The degree of success or failure depends largely on how well the functionally generated path technique is carried out. The functionally generated path record determines, to a large extent, how effectively optimal functional occlusion will be produced in the finished castings. This critical procedure is carried out as follows:

*The term "functionally generated path technique" corresponds to the terms "functional chew-in technique," "functional bite technique," "generated path technique," and "cuspal tracing technique." All of these terms imply a *controlled* activity by the patient, and the techniques are used to develop the basic forms of the contacting parts of occlusal surfaces of restorations.

Correcting the Incisal and Occlusal Guide Castings in the Mouth.—The cuspid castings (or substitute first bicuspid castings) are seated in the mouth. *They are perfected by selective grinding until the ideal centric and eccentric jaw relationship exists with these teeth acting as a guide.* The teeth are dried, and 2-inch strips of different colors of tabulator ribbon* (red for centric contacts and purple for eccentric tooth contacts) are used to mark the occlusal pattern.

The patient is instructed to "tap, tap, tap,"[3] and the centric relation is established at the desired vertical dimension, making sure that both "incisal guide" castings contact *simultaneously, firmly, and solidly without a slide or skid of any kind. The imprint of the pattern of the red silk fibers must be seen on the guide castings.*

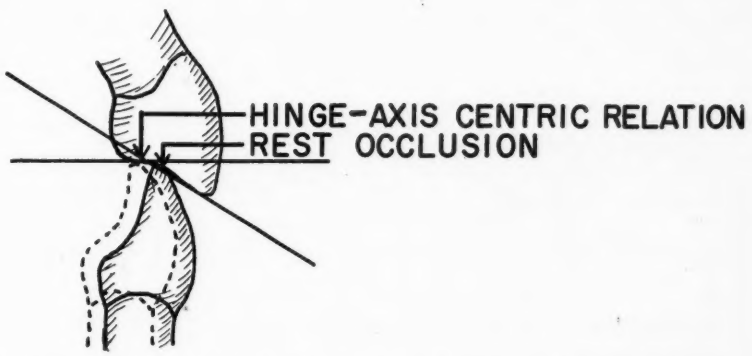

Fig. 3.—"Long centric" occlusion. The freedom of movement provided from the hinge-axis centric relation to rest occlusion is called "long centric" occlusion. To develop this freedom, the condylar spheres (in the condylar guidances of the articulator) are set in a protrusive relation either by placing metal strips in front of them or by using the P-R (protrusive-retrusive) adjustment of the Hanau articulator. Then, the cuspid wax pattern is carved to accommodate this relation in rest occlusion and the incisal guidance. After this is done, the condylar adjustments are reset to the hinge-axis centric relation and the pattern carvings are extended to contact in this position.

Then, with the purple tabulating ribbon between the teeth, the patient is instructed to "grit on his back teeth," guiding the jaw laterally. This will register the contacts within the envelope of function. The patient is directed to "tap, tap, tap" on the red silk again, and we *never touch these red marks.* The corrections for eccentric prematurities are made on the *purple markings only,* and the castings are shaped to develop the most ideal eccentric functional relation possible. (Fig. 4.) When the corrections of the "guide castings" are completed, the teeth should be in the optimal occlusion. *These castings will be the guides for all functional occlusal reconstruction of the upper posterior teeth.*

The Functionally Generated Path Record.—Distortion of wax interocclusal records may be caused by two factors: (1) the hardness and/or bulk of the wax and (2) the rebound of the wax itself displacing the condyles. This distortion can be prevented by the functionally generated path record technique if it is properly carried out.

*Madam Butterfly pure silk ribbon, Goldsmith Brothers, 77 Nassau St., New York 8, N. Y., or Miller-Bryant-Pierce, Aurora, Ill.

The cuspids have been corrected to the exact vertical dimension and centric and eccentric occlusions, and the desired "cusp rise" has been established. Even more important, *nothing is touching in back of the cuspids. The condyles are not pulled out of position or displaced.*

The previously constructed metal generated path tables are seated and corrected as follows: The metal tables are relieved until a clearance of at least 0.5 mm. is obtained between them and the lower teeth in all excursions. However, the clearance between the buccal cusps of the lower bicuspids and the generated path table may be less, for esthetic purposes. *There must be no contact in back of the cuspids, so the condyles are not pulled out of position or displaced.* A special, soft registration material* is added to the top of the generated path table, and the patient is instructed to use this stable base to perfect the functionally generated path record.

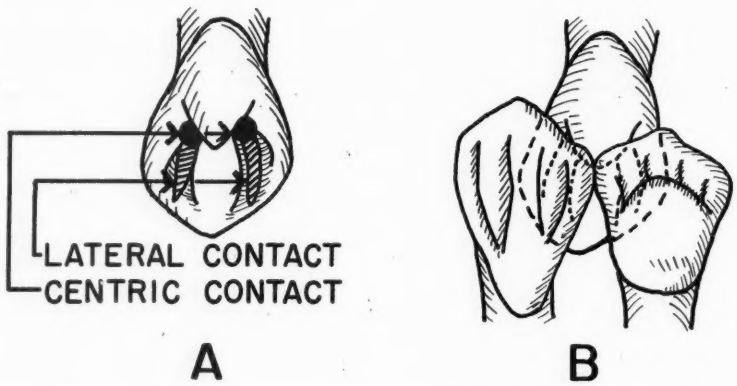

Fig. 4.—*A*, The areas of contacts by the lower cuspid and first bicuspid teeth on the lingual surface of the upper cuspid. The contacts in centric occlusion are marked in the mouth with red tabulator ribbon. The contact area in lateral occlusion is marked in the mouth with purple tabulator ribbon. *B*, Lingual view of the mesiodistal relationship of the upper cuspid to the lower cuspid and first bicuspid. This relationship directs stress along the long axis of the upper tooth.

The patient is instructed to make a "power bite" in centric position, then open and contact the opposing tips of the cuspids, and glide the teeth back to centric occlusion on the working side. This procedure is repeated on the opposite side, thereby establishing the balancing side. (By moving the jaw from eccentric position to centric position, rather than from centric position to eccentric position, the recording material does not have the tendency to "ball up.") This functionally generated path record is removed and examined with binocular loupes. Any defects, such as voids, dragged material, or wrinkles, in the record are corrected. The excess recording material is trimmed away, and the generated path record is returned to the mouth for final checking. *The cuspids must contact firmly in all oc-*

*Tackywax, Harry J. Bosworth & Co., Chicago, Ill., or Adaptol, J. F. Jelenko & Co., New York, N.Y.

clusal relations. The functionally generated path records are always placed in tap water as soon as they are removed from the mouth and are kept there until used.

A centric relation record (as described in Part I) is made in Aluwax, and the lower cast is remounted on the articulator. After this lower cast has been remounted, the mounting ring and cast are removed and another mounting ring is substituted on the articulator.

TRANSFER OF THE FUNCTIONALLY GENERATED PATH RECORD TO THE ARTICULATOR

The "guide castings" are returned to their original positions on the master cast, and the incisor teeth on the upper cast are shortened 1.0 to 2.0 mm. and leveled off to form a flat seat for the stone index to be poured against them. *The condyle mechanism of the articulator is locked in centric position. It is kept locked in centric position during the remaining procedures. The articulator functions only as a hinge (plane-line) articulator.*

All except the most mesial and most distal dies are removed from the cast. The functionally generated path table is placed in position on the master cast and sealed wtih Stickywax. The flattened incisal edges of all of the upper anterior teeth are boxed in, labially and lingually, with stick utility wax.* Hard stone is gently vibrated over the wax generated path record and onto the flattened incisal edges of the upper anterior teeth. This stone is built up to a thickness of ½ inch. Hydrocal is poured on the lower mounting plate to within ½ inch of the poured functionally generated path record. After both stone mixes are thoroughly set, they are united with Hydrocal. This procedure will minimize the dimensional change which would occur if the wax generated path records were poured and attached to the lower member of the articulator with one mix of stone.

FABRICATING THE WAX PATTERNS

The lower anatomic cast mounting is substituted for the functionally generated path mounting on the articulator, and the wax patterns for the restorations on the upper teeth are carved. The stone functionally generated path index mounting is then substituted for the anatomic cast on the articulator, and the wax patterns are corrected. To do this, talcum powder or white shoe polish is applied to the stone generated path index and the index is tapped gently against the wax patterns several times. All interferences as indicated by the transfer of the white material to the wax are removed, and an even pattern of occlusion is developed. This procedure must be continued until the stone "stop" (made by the flattened incisal edges of the anterior teeth) makes a definite and firm contact. Then the wax patterns are removed, invested, and cast, and the castings are returned to their respective dies on the articulator.

Prussian blue† is applied on the stone generated path index on the articulator. The Prussian blue will mark the high spots on the castings when the index is

*Kerr Manufacturing Co., Detroit, Mich.
†Pittsburgh Plate Glass Company.

tapped against the castings. The contacts are corrected by grinding until an even pattern of occlusion results and until the anterior "stop" is again completely closed. During this entire procedure, the articulator is locked so it can move only as a hinge, without lateral or protrusive movement.

FINAL ADJUSTMENT AND CEMENTATION OF UPPER CASTINGS

If the technique has been followed meticulously up to this point, final corrections in the mouth will be a minimum. These are carried out as follows:

The guide castings (for the upper cuspids) are returned to their original positions in the mouth. The posterior castings are tried in for fit, and the margins are checked by roentgenograms. The castings are removed, the contact areas are perfected, and the proximal surfaces are finished. The guide castings for the upper cuspids are *not adjusted or changed in any way.*

Either the casting for the first bicuspid or the next casting distal to the guide casting is placed in position on the tooth it is to restore. Then the procedure for correcting the occlusion is carried out in *three steps:* (1) centric occlusion, (2) envelope of function on the working side, and (3) the balancing side. Each casting is corrected individually in all these positions before the next casting is inserted.

Corrections in Centric Occlusion.—The upper casting is adjusted in centric occlusion until the fiber pattern of the red tabulator ribbon is identical with that on the cuspids. Then, the patient is asked for the first time, "Which one is highest?" The final corrections are made with a Burlew sulci polisher. (For occlusal correction, in addition to the silk fiber tabulator ribbon and the patient's evaluation, there are many other aids, such as 30-gauge green casting wax, dryfoil, percussion sounds with or without a stethoscope, digital evaluation, etc, and all have their use.)

Corrections on the Envelope of Function on Working Side.—The working-side occlusal contacts are corrected to conform to the contacts on the lingual incline of the upper cuspid on that side. Purple tabulating ribbon is used in this lateral occlusion. Care is taken to avoid touching centric occlusion markings at this time. Grind on the purple marks only. *Never grind the red marks* after centric occlusion has once been established and corrected. (To guard the centric occlusion, always have the patient "tap, tap, tap" on the red silk ribbon in *centric position each time after* the working inclines are marked in purple.)

Corrections on the Balancing Side.—The occlusion is checked on the balancing side by placing a suitable width of green tabulating ribbon over the tooth to be checked and instructing the patient to close first in centric occlusion, then to move the jaw to the working side. Any interference on the balancing side will be indicated by markings on the buccal incline of the upper lingual cusp and/or the lingual incline of the lower buccal cusp. Correction of interferences is made by grinding either incline, without shortening the centric occlusal contact. The cusp areas that contact in centric occlusion must not be touched. We prefer to make this correction on the upper restoration. *The balancing side contacts are relieved until the buccal incline of the upper lingual cusp and the lingual incline of the lower buccal cusp are entirely free* and the silk ribbon will pull through while the teeth are in contact on the opposite (working) side.

All of these procedures are repeated for each of the remaining castings. Then the markings on the cuspids are removed, and the "new casting" is adjusted until the cuspid markings show up as originally noted.

The casting for the most medial tooth on the opposite side is corrected in a similar manner. This procedure is repeated for each of the remaining castings in turn, first on one side then the other, and *progressing distally from the medial casting* until all castings have been checked out. Then, all of the castings are removed, polished, and cemented with the same procedures as described for the lower restorations (Part I).

DISCUSSION

The four prime objectives of oral rehabilitation are: (1) optimum oral health, (2) functional efficiency, (3) mouth comfort, and (4) esthetics.

We believe that the technique described accomplishes the objectives of oral rehabilitation better and in a more practical way than other techniques. It makes possible the reconstruction of the occlusion so that all functional structures (the teeth, periodontium, muscles, ligaments, and temporomandibular joints) may attain *optimum health.*

Many advantages result from completing the lower reconstruction before starting the work on the upper teeth. Discomfort is minimized because only one arch is operated on at a time. We are able to complete the work on the lower teeth more rapidly, so the patient is not required to wear temporary restorations for an extensive period of time. In case of emergencies, it is usually possible to complete the lower restorations, remove the premature contacts on the upper teeth, and send the patient on his way enjoying comfort and efficiency until such time as he can return for the upper rehabilitation.

This technique can be used in many dental offices and can be adapted to the facilities usually available to dentists and dental technicians. The instruments used in the technique are not complicated. Only the P-M instrument is needed in addition to the usual dental instruments. Extensive and complicated extraoral registrations of functional jaw movements are eliminated. Procedures are simplified, so there is less chance for compounding errors. However, ***one absolute prerequisite to the carrying out of any oral rehabilitation procedure is that the dentist must possess a thorough knowledge of occlusion and then proceed to obtain the most ideal occlusion for his patient.***

SUMMARY

1. The objectives of oral rehabilitation have been discussed.

2. The procedures used to reconstruct the most acceptable, functional occlusal plane on the mandibular posterior teeth using the P-M instrument have been described (Part I).

3. A functionally generated path technique, utilizing guide castings on the upper cuspids to control the development of a functional occlusion, has been described.

4. The advantages of these techniques have been discussed. The use of interocclusal wax functionally generated path records made on functionally generated path tables makes it possible to eliminate all occlusal interferences and establish the functional form of the occlusal surfaces of the restorations.

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GOLD COPINGS FOR PROBLEMATIC TEETH

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IT IS FREQUENTLY advantageous to be able to use teeth with doubtful longevity as abutments for a fixed or removable prosthesis or as units of a multiple splint. Teeth with periodontal involvement, pulpless teeth, short-rooted teeth, teeth with narrow, tapered, single roots, and some teeth with bifurcation or even trifurcation involvements *may* be used as abutments if they are properly protected.

GOLD COPINGS

Such problematic teeth may be covered with thin gold copings. These copings are cemented permanently to the prepared teeth before the telescoping overlay crowns are made (Fig. 1). When the teeth are protected by gold copings, temporary cement can be used to secure the fixed partial denture or splint in position. Without such protection, a temporarily cemented fixed prosthesis cannot remain in the mouth long, because of cement destruction by the mouth fluids and resultant caries. This situation is especially dangerous when the restoration is cemented temporarily to multiple abutments. The temporary cement on one or more of the abutments may leak without being detected, while the other abutments retain their cement and give a false impression of good retention. Unprotected teeth with no cement are subject to severe caries before the fault can be detected. The permanently cemented gold copings underneath the crowns of the fixed partial denture or splint prevent the development of caries when the temporary cement becomes defective. The gold copings cover and protect the individual teeth if the temporary cement washes out.

If the problematic tooth must later be removed, the temporarily cemented prosthesis can be removed easily and the condemned tooth extracted. Then the crown which had covered the coping can be filled with plastic, silicate cement, or gold. Thus, the same fixed partial denture or splint can be recemented and made still serviceable to the patient.

Other Uses for Copings.—Gold copings can be used to make abutments parallel as well as to protect teeth. Teeth which are not parallel can be covered by gold copings shaped so they are parallel to the other abutment preparations or castings. The telescoping crown that goes over the coping does not have to extend to the gingival margin of the tooth. It needs only to extend far enough to provide retention and at the same time be parallel with the other abutment castings on the restoration.

Presented as a projected clinic at the Greater New York Dental Meeting, New York, N. Y.

Fig. 1

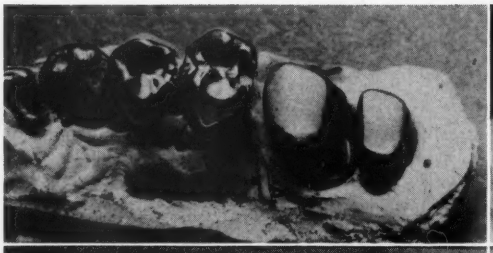

Fig. 2

Fig. 3

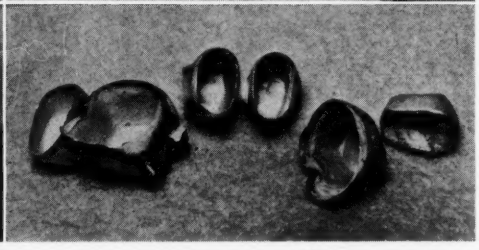

Fig. 4

Fig. 1.—The bicuspids and molars will be splinted together. There is a deep pocket between the molars. Thin gold copings are in place on the molars. The bicuspid veneer crowns are soldered together.

Fig. 2.—A screw fits into the small hole in the lingual surface of the first molar coping to provide mechanical retention for the telescoping overlay castings.

Fig. 3.—The threaded tubing that accommodates the retention screw is in position in the wax pattern.

Fig. 4.—The various parts of the completed fixed partial denture before insertion in the mouth. The molar trifurcation involvement is indicated by the contour of the molar casting. The screw is in position in the casting and will help secure it to the coping.

Fig. 5

Fig. 6

Fig. 5.—The copings are secured separately with a permanent cement; then the bicuspid veneer crowns are cemented.

Fig. 6.—The molar splint is attached to the gold copings with a temporary cement, and the screw is inserted from the lingual surface. The molar crowns are removable, which permits easy access for periodontal treatment.

RETENTION

The cast crown which covers the coping should be held in position by active mechanical retention in addition to the temporary cement. Mechanical retention can be accomplished by placing small screws* in advantageous positions through the crowns and into the copings (Figs. 2, 3, and 4). The tube to carry the screw is made a part of the overlay casting. Care should be taken to avoid drilling the hole for the

*Distal extension screw and round tube, The J. M. Ney Co., Hartford, Conn.

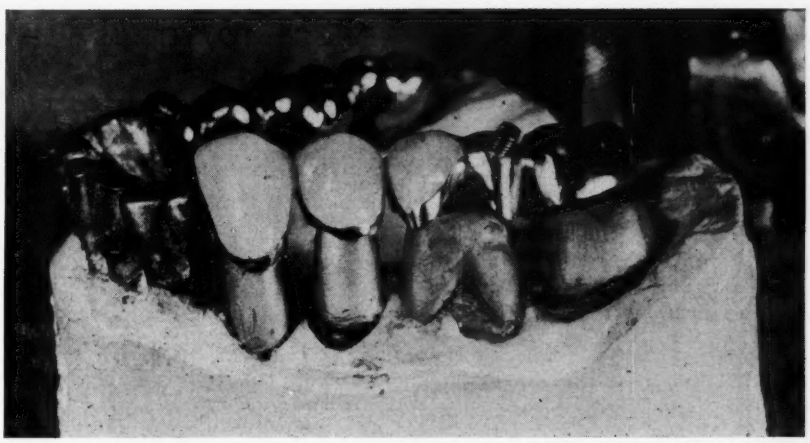

Fig. 7.—The gold copings will be attached with permanent cement. The overlay splint will be secured with temporary cement. The screw is in the buccal surface of the first molar casting. There is a similar splint on the right side.

Fig. 8

Fig. 9

Fig. 8.—The copings are joined by a flat gold bar. The hole in the bar for the screw provides for positive retention without the danger of perforating an abutment coping.

Fig. 9.—The telescoping overlay fixed partial denture for the copings shown in Fig. 8. The receptacle for the screw is between the teeth.

screw too deep and perforating the coping. If the tooth should be exposed through the coping, silver nitrate is applied and the exposed surface is watched carefully. A silver filling can be inserted if caries develops.

The screws are inserted after the fixed partial denture or splint is secured in place in the mouth with a temporary (zinc oxide and eugenol) cement (Figs. 5, 6, and 7). There are several advantages in the use of a temporary cement. There is no chance for saliva to seep into the gold joints and to produce a foul odor because of its stagnation. Leaks in the overlay crowns may be detected by looking for brown oxidation when the fixed partial dentures are removed.

When there is a space between teeth, the copings can be connected by a rectangular gold bar and the retaining screw can be inserted into this bar rather than into some portion of the abutment coping (Figs. 8 and 9). This form of positive retention is effective and less dangerous to the tooth.

Fixed partial dentures or splints constructed in the manner described may remain in position from 1 to 6 months. If the mouth requires frequent prophylaxis or periodontal treatments, the prosthesis is removed. The periodontal pockets are far more accessible for treatment with the dental prosthesis removed.

SUMMARY

With the increased use of multiple splints and extensive dental reconstruction, gold copings under crowns provide an additional tool for the dentist. More questionable teeth may be retained. The copings permit thorough prophylaxis, provide a method of paralleling teeth without removing their pulp, and permit restorations to be cemented temporarily without endangering the abutment teeth.

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PARTIAL VERSUS FULL COVERAGE

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CURRENT PRACTICES in the preparation of teeth are wasting irreplaceable enamel. Sturdy and skillful methods have fallen by the wayside and have been replaced by a substitute, full coverage. Full coverage is far easier to use than partial coverage because it is faster, there is less margin with which to contend, and in reconstruction procedures the convenience is extremely advantageous. However, how about the harm to the teeth we prepare? Is full coverage truly the superior restoration? Do we actually experience fewer marginal failures?

The incidence of failures with partial coverage, when judiciously and correctly used, has been less than that with full coverage under similar circumstances. Recent and highly accurate impression methods permit a hurdling of the margin problem in partial tooth coverage, there is less harm to prepared teeth, more guides are present to aid in carvings and proper contours, and, in many instances, we are able to *conserve tooth structure.*

Several types of preparations and certain failures helped swing the pendulum of preference toward full coverage. There is a mild reversal, however, toward an approach which requires a more careful analysis of each situation. The purpose of this article is to describe an approach to circumvent these failures and thus provide a satisfactory restoration which employs the principles of sound engineering and down-to-earth conservatism. Thus, the indiscriminate use of full coverage for all teeth can be avoided.

THE GOLD INLAY

The conventional and familiar gold inlay with its occlusal bevel is basically a poorly designed restoration. Some of the inherent disadvantages are: (1) The very nature of its design prevents alteration of occlusal disharmonies. (2) The greatest wear occurs at the cavosurface bevel, and, in many instances, this wear leads to seepage, recurrent caries, and eventual failure of the restoration. (3) A

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casting so designed splits the tooth buccolingually because the entire inlay lies within the cavity walls and acts as a wedge to set up future lines of fracture. (Fig. 1.) The conventionally designed gold inlay is not a restoration of choice. The gold partial coverage casting has been developed into a far superior restoration.

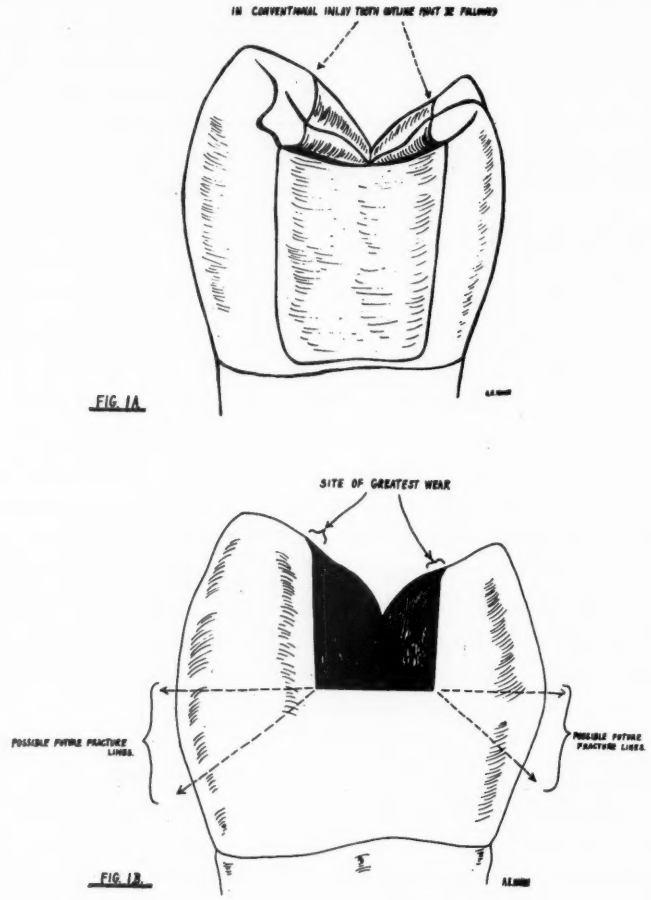

IN CONVENTIONAL INLAY TOOTH OUTLINE MUST BE FOLLOWED
FIG. 1A.
SITE OF GREATEST WEAR
POSSIBLE FUTURE FRACTURE LINES.
POSSIBLE FUTURE FRACTURE LINES.
FIG. 1B.

Fig. 1.—*A*, It is impossible to correct gross occlusal disharmonies, because the occlusal outline of tooth must be followed. *B*, The greatest wear occurs at the cavosurface bevel and may lead to seepage. The arrows indicate possible future fracture lines.

THE THREE-QUARTER CROWN

The failures encountered with the inlay led to widespread use and acceptance of the three-quarter crown, particularly in fixed partial denture prosthesis. According to Gillett,[1] various preparations for the three-quarter crown were devised by Carmichael, Ward, Tinker, and others. Many felt Carmichael's grooved preparation caused pulpal damage, although his reason for use of such a restoration was to conserve tooth structure. Ward's and Tinker's early three-quarter crown prepara-

tions called for a profound sacrifice of tooth structure. The cervical shoulder was carried out unbrokenly around the entire tooth except on the labial or buccal surface. Many dentists concluded that this attachment covered too much tooth structure and that many pulpal deaths were caused by this procedure. Ward and

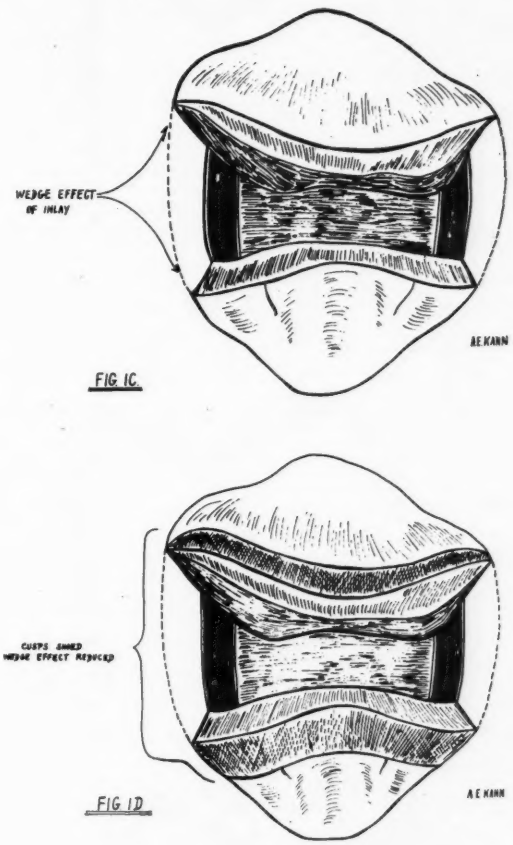


Fig. 1.—*C*, The entire inlay lies within the cavity walls and acts as a wedge to set up future lines of fracture. *D*, The shoeing of cusps prevents possible future fracture lines by containing the buccal and lingual walls.

Tinker modified their preparations to conserve tooth structure,[1] and these preparations were the forerunners of the MOD onlay. In effect, the MOD onlay is but a minor modification of their earlier work.

These excellent modified preparations gave way to modifications of the earlier Carmichael design. Many failures were observed and experienced with this restoration because, as with the inlays, the design incorporated weak mechanical links in its structure. In the lower dental arch, the incisal or buccoclusal bevel would, because of its design, show excessive wear with eventual seepage and failure. The crowns were constructed with insufficient thickness and eventually spread under the stresses of occlusion. Failure was the inevitable result. (Fig. 2.)

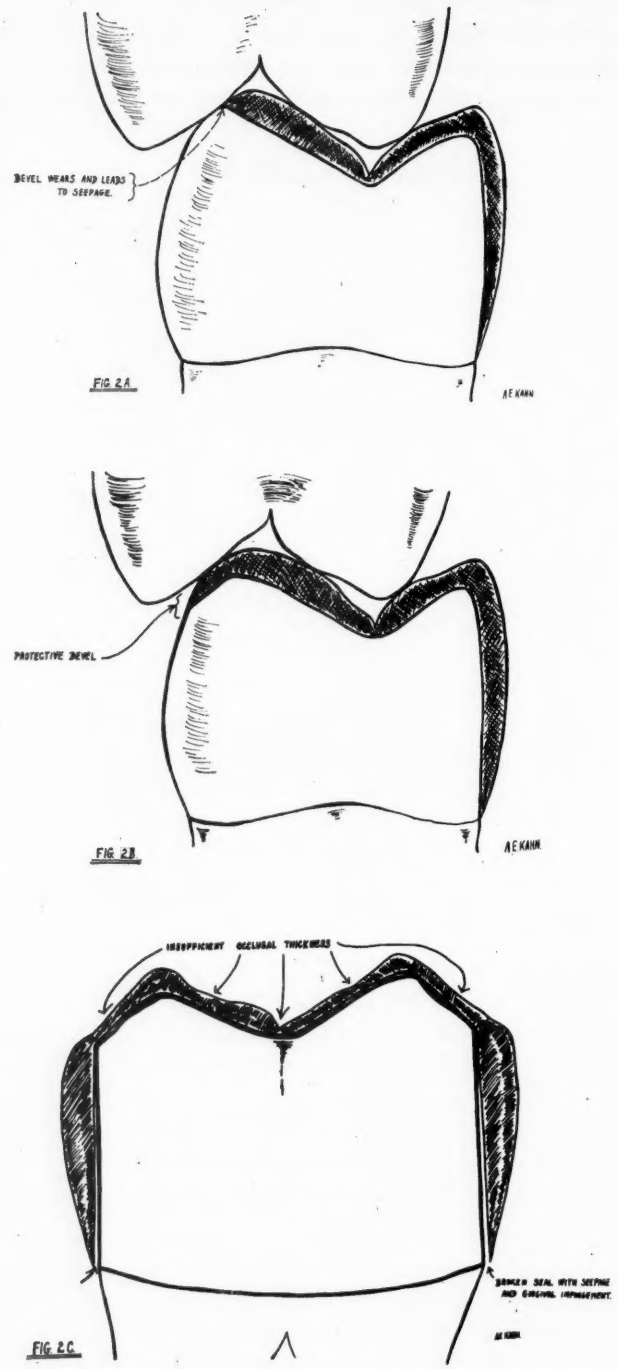


Fig. 2.—*A*, A bucco-occlusal (or incisal) bevel leads to excessive wear with eventual seepage. *B*, The proper bucco-occlusal (or incisal) bevel is way from areas of tooth contact, thus preventing wear and seepage. *C*, Insufficient thickness leads to an eventual spread of the casting.

THE PINLEDGE CASTING OR ATTACHMENT

The pinledge casting is an almost forgotten restoration. It has many uses and advantages over other retainers, however, particularly in the lower anterior segment of the mouth. A most difficult situation is created, for example, when one lower incisor (or more) is lost. The pinledge attachment provides a satisfactory means to remedy such conditions. The pinledge casting is valuable also when multiple splinting is required.

The pinledge casting has almost disappeared as a restoration because (1) use of the preparation requires much training and individual skill, (2) the creation and paralleling of the pins are difficult, and (3) the reproduction of the pins in impressions and subsequently in casting poses further problems.

FULL COVERAGE TREND

The difficulties with the preparations just discussed raised doubts as to whether they should not be discarded altogether. Therefore, the pendulum started to swing toward full coverage as the restorative procedure of choice. The movement was given added impetus by the surge of interest in oral rehabilitation and in speed. The movement was natural since it fit into a very definite pattern. Many dentists spread the concept of the full crown, and it became well implanted within a comparatively short time. After a number of years, however, some of these same dentists advocated a return to partial coverage, *where indicated*.

CONSERVATIVE APPROACH

The conservative approach means that dentists have a *great responsibility* to evaluate carefully and select the restoration most ideal for each specific situation. For example, if the mouth has a high caries index, full coverage is the medium of choice. Malposed teeth which can be brought into more favorable relationship by the use of more complete coverage should be treated similarly. If the mouth has an average or a relatively low caries index, however, partial coverage is best even if multiple restorations are necessary for occlusal rehabilitation. Full coverage in such a mouth would be nothing less than wanton destruction of tooth structure.

Several important factors must be considered when using full coverage. Can we be certain that the restoration has been properly seated during cementation? I have not always been successful in this respect. Some dentists recommend drilling occlusal, buccal, or lingual holes in full restorations to create an escapeway for the cement. These perforations are closed later with gold foil. Is this an ideal restoration?

Hydraulics is important in the process of cementation of full crowns, and may cause pulpal death. Whether the death of the pulp is from the oxyphosphate cement or from the pressure created by the hydraulics (or perhaps from overheating the tooth), I do not know. However, there is, relatively, a higher ratio of pulpal death of teeth which receive full coverage than of those with partial coverage. In view of such information, we should become more selective, evaluate each situation carefully, and use full coverage only where absolutely necessary.

Some dentists feel that permanent cementation is not necessary and that by resorting to provisional cementation many of the disadvantages of full coverage may be avoided. This is true and in many instances good, sound procedure, but temporary cementation poses problems of its own. Extensive splints are difficult to remove, and as a future aid in removal, a diluent such as petroleum jelly is added to the temporary cement. This makes the removal of the splint simpler but does not obviate the washing out of the cementing medium with accompanying recurrent caries, which can effect considerable damage. Furthermore, in the removal of castings for recementation, a fractured tooth (or teeth) is another serious problem.

Many dentists consider possible pulpal damage and eventual pulpal death unimportant. They believe that endodontic treatment completely negates this factor. Added to this is their belief that the pulp is not necessary to the continued maintenance of the tooth. This kind of thinking is extremely dangerous, for it can lead to an era of carelessness without equal in all of dental history. Already there exists too much disregard for pulp tissue, without an attempt to promote further disregard for it.

Not all root canal treatments are successful, and many teeth so treated are subsequently lost. Also, the atypical root anatomy of many teeth prevents endodontic treatment from being carried out at all.

We cannot ignore the painful experiences patients are subjected to when pulpal damage occurred. Let us aid Nature rather than dictate what is and what is not expendable.

ADVANTAGES OF PARTIAL COVERAGE AND THE MOD ONLAY

Partial coverage castings create fewer problems than full coverage castings. The advantages of the partial coverage casting will be discussed.

Margin Factor.—Even though there is less margin length in full coverage, there are many ill-fitting crowns. This failing is not in the restoration, however, but rather in the techniques and individual standards used in fabricating the patterns and castings. The mere fact that a full crown has less margin than an MOD onlay does not in itself justify the use of the crown. If both types of restorations are well adapted, it does not make any difference, except in a highly carious mouth where the full coverage casting is the restoration of choice. Under circumstances of an average caries index, each restoration, properly constructed, is as sturdy as the other regardless of marginal length.

Gingival Irritation.—The ratio between the margin factor and gingival irritation is important. Even though the linear margin of a full crown is far less than that of an MOD onlay, the partial coverage casting actually has less margin in contact with gingival tissue since such contact is only in the proximal regions. Elsewhere, on the buccal or labial and lingual surfaces, the margins are well away from the gingival tissue.

Loss of Helpful Guides.— Many helpful guides are lost in occlusal rehabilitation where full coverage is used. Interdigitative relations of teeth are more difficult

to establish because of the large element of guesswork concerning size and contour. Furthermore, because of the lack of uniformity of concept in regard to the architecture of teeth, crowns will vary in form and contour. If ten dentists were to carve many full crowns for a patient, these crowns would bear little recognizable relationship one to the other. If partial coverage were used, however, a uniform resemblance could more easily result because there would be more guides to aid in establishing proper form and contour. (Fig. 3.)

Embrasure Space, Labial or Buccal and Lingual Contour.—Full coverage presents more problems than does partial coverage in regard to proper contours in all dimensions. Again, ten different dentists would have individual concepts as to what is meant by proper contour, and more restorations would be contoured *improperly* than not. This would not be so with partial coverage since more helpful guides are present. The embrasure spaces would be respected, and the labial and lingual contours would more than likely be correct. The importance of these proper contours will be discussed along with the periodontal aspects of restorations.

Plastic Problem.—Plastic veneers are not a problem with partial coverage castings. Plastic veneers wear away in function, and as they do, the labial or buccal contour is lost and with it goes the marginal tissue protection. The porcelain-veneer castings obviate the plastic problem, but they create some difficulties of their own, such as color, breakage, and necessary bulk (particularly at the gingival margin).

Pulp Problems.—Far more pulp problems are evident with full coverage than with partial coverage. Some of the reasons are the gross and rapid removal of tooth structure, overheating during operative procedures, the effect of hydraulics during cementation, the gross exposure of prepared tooth surfaces to saliva and/or oxyphosphate cement, and the overpreparation of teeth, which, in many instances, is necessary to achieve parallelism.

Bender, Seltzer, and Kaufman[2] reported that the full crown preparation may open the way to bacterial infection of the pulp via the dentinal tubules. They state that full crown preparations should be limited to situations where they are an absolute necessity because of the hazards to the pulp. "Conditions for penetrating of dentin by microorganisms are favorable particularly during preparation of full crowns. Large numbers of tubules are opened, preparations are often made deep in order to obtain parallelism, considerable force is exerted to make impressions and the dentin is bathed in saliva for long periods. The bacteria, lodging in a tissue already inflamed by grinding, heat and pressure, may provide the extra increment of irritation which finally overcomes the recuperative power of the pulp; or the flare-up may be temporarily postponed until additional trauma (as from the acidity and pressure of cementation) is accumulated."

Noncarious teeth which are used as abutments are another factor. When these teeth are prepared for full coverage, the rapidity of the cutting procedure does not allow for the laying down of secondary dentin as part of the physiologic response of the tooth. The invasion is sudden and totally unlike the gradual response evoked by the stimuli of abrasion and/or caries. The result could well be a hyperemia of the pulpal tissue with possible subsequent degenerative changes.

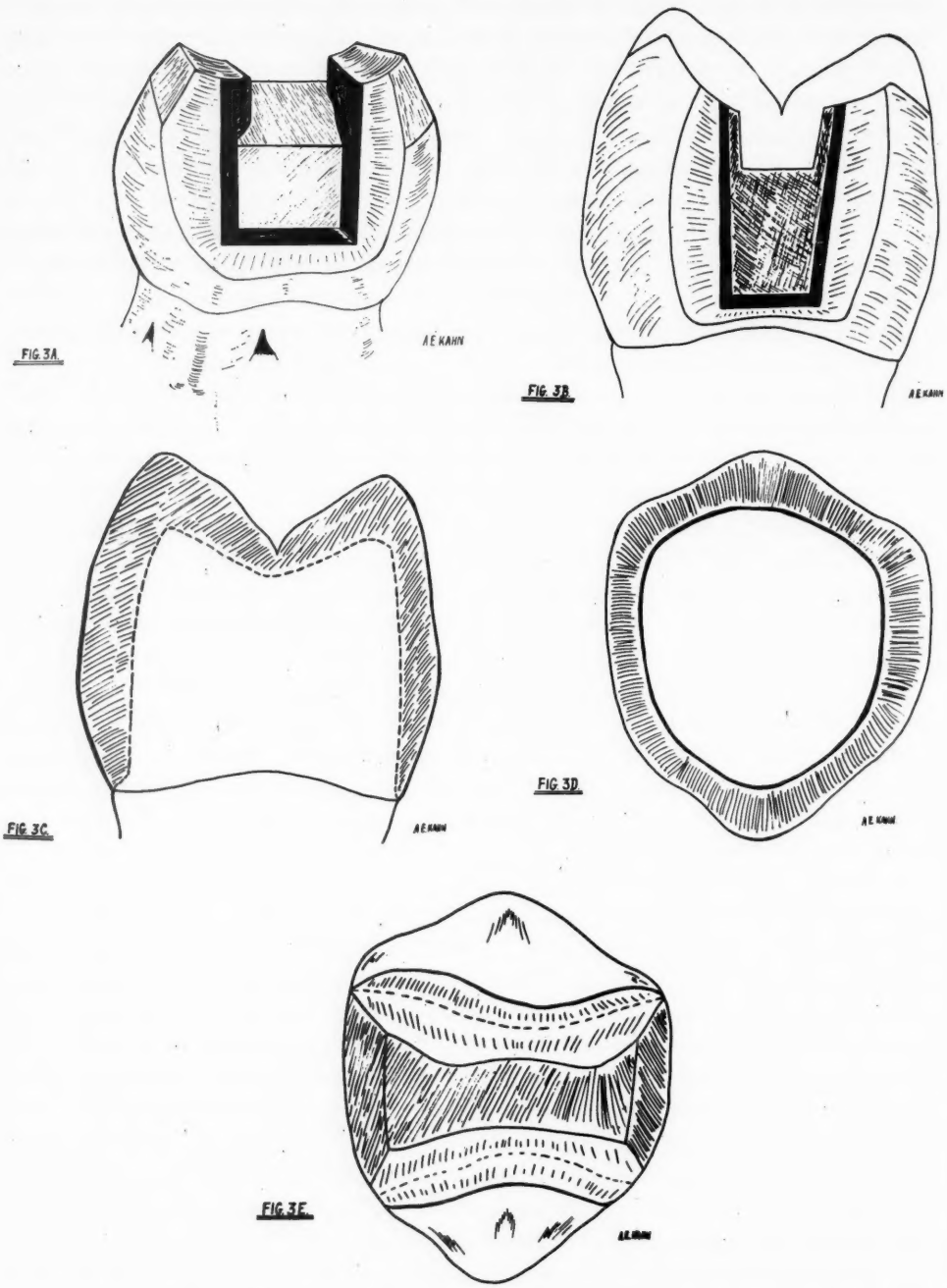


Fig. 3.—*A*, Many guides are present in an MOD onlay preparation as an aid in carving proper form and contour. *B*, Note the guides for contour. *C*, The shaded area indicates how much form and contour are left to the imagination of the dentist in full coverage restorations. *D*, Note how the unshaded inner stump projects practically no guides for form and contour. *E*, When partial coverage is used, the valuable guides so necessary for proper form and contour are present. The buccal and lingual walls are intact.

Positive Seating During Cementation.—The seating of an MOD onlay does not generate much hydraulic pressure during cementation because escapeways are already present. The buccal and lingual bevels reveal whether or not a proper seat has been obtained each time a casting is cemented.

Vertical Dimension.—When all remaining teeth are reduced for full coverage, the re-establishment of the proper vertical dimension is a difficult problem. Many complete dentures fail because of an erroneous concept of what the correct vertical dimension of occlusion should be. Yet, occlusal rehabilitation often completely destroys the guides we so often wish we had for complete dentures.

DISADVANTAGES OF PARTIAL COVERAGE

Some dentists disfavor partial coverage because teeth can be prepared more easily for full coverage. However, this is not a valid reason for using full coverage. If one practices to master the more difficult partial coverage preparations, he will increase his skills. He will become a better dentist, be more thoroughly equipped to handle all situations, and thus set in motion the influences so necessary for professional growth.

Improved esthetics is another argument that is raised by the proponents of full coverage. What does one do when patients object to the display of gold? This is a difficult situation, and many compromises must be made. However, the compromise does not have to be complete. Full coverage can be used on the few teeth which would alter the esthetics if metal was to show. There is no escape from the fact that we must be practical. A strong argument by the dentist, however, listing the pros and cons of each preparation and restoration, may eliminate patient objection.

Why is it that this problem of esthetics is mainly a geographic one, confined mainly to the Eastern Seaboard (and to a lesser degree to certain parts of the Midwest and West Coast)? Is it possible for people to differ so markedly in their likes and dislikes in regard to visible metal merely because they are from different locales? Or have we dentists planted these seeds of objection? Perhaps more emphasis has been placed upon esthetics than on sound treatment principles and restored function.

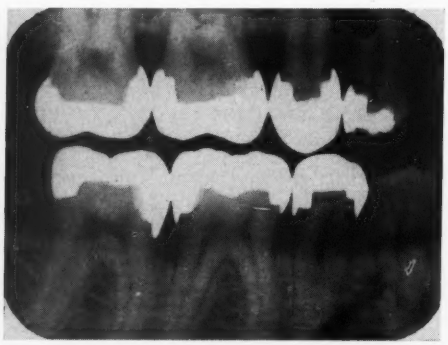
Still another argument might be raised concerning periodontal involvement. Subgingival extensions are often necessary for the continued health of the periodontium. This does not mean one treatment for all, however, since we do encounter many variations. Much irreparable damage has been created by following the principles of a "stock format" for every patient. In many instances, teeth have been reduced to the shape of toothpicks, intolerable degrees of sensitivity produced in patients' mouths, and, because of pulpal damage, many future candidates for endodontic treatment created. It is not logical to reduce teeth of bulbous contour for full coverage even at the risk of mechanical pulpal exposure. It does not make good sense to prepare periodontally involved teeth, with their lengthened clinical crowns, by reducing them for full coverage regardless of the consequences. Each tooth should be evaluated carefully, and what is best for each one is what should be used. We must vary our diagnoses to meet each situation.

DIFFERENTIAL DIAGNOSIS

The element of future diagnosis is important in the choice of the restoration. Consider a mouth reconstructed with full coverage in which the patient develops symptoms of pulpitis or necrotic pulp. Where does one start in making a differential diagnosis to locate the affected tooth (or teeth)? The usual methods of pulp testing are ineffective with full coverage. In some instances, the problem is eased by sensitivity to percussion, but this symptom may be absent. Diagnosis, even by thermal tests, often gives obscure or confusing results. If partial coverage castings are used, however, the problem of rendering a differential diagnosis is simplified because *unaltered tooth structure* may be tested. Thus, the perplexing factors are greatly reduced.

PERIODONTAL HEALTH

Periodontal health is one of the most important considerations in dentistry. Without a healthy (or controlled) periodontium, everything else becomes meaningless. The realization that the mouth functions as an entity rather than in separate segments vividly demonstrates that restorative methods eventually build roads, all of which lead to the final point of reckoning, the periodontium. We have many differing opinions and controversies on what is the best type of occlusion, which



A.

B.

Fig. 4.—*A*, and *B*, The guides serve as a valuable aid in re-establishing proper form and contour in partial coverage. No matter how much individual concepts vary, the natural tooth guides are more likely to lead to correct form and contour. Also, greater care for the embrasures exists in partial coverage.

articulator is best, one preparation or one impression technique versus another, which type restoration is more ideal, etc. However, the periodontium is the most common meeting ground. It must appear identical to all eyes.

The choice between partial or full coverage can influence the health of the periodontium. With partial coverage, we have guides for the restoration of lost tooth structure. Thus, we are able to re-establish proper tooth contour without much difficulty (Fig. 4). With full coverage, however, all of the guides are lost, and the tooth contour is strictly up to the imagination and knowledge of the dentist. In many instances, because of the absence of guides, the crowns are so

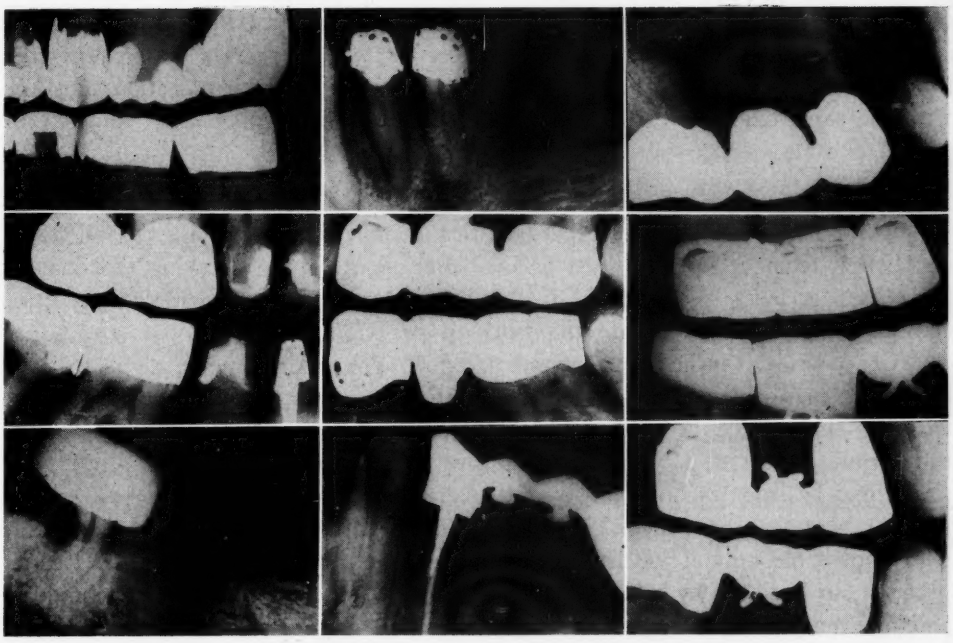


Fig. 5.—In nine different situations of full coverage, the dentist's concept of proper form and contour varies because of the lost guides. Note the ill-fitting margins, encroachment on embrasure spaces, and contacts improperly placed or missing.

Fig. 6.—The periodontal health is maintained more easily when the buccal (and lingual) margins of the restoration are well above the gingival tissue.

shaped as to cause damage to the periodontium. The result of improperly shaped crowns is an inevitable breakdown of the periodontium, particularly in a mouth in which multiple restorations have been placed (Fig. 5).

The increased skill required for making partial coverage restorations creates superior restorations with well-adapted gingival margins. This prevents damage to the periodontium. Relatively, a lesser degree of skill is required for making full crown preparations. *Fairly* accurate impressions can be made without too much

difficulty, and *some sort of fit* is obtained except where gross distortion has occurred. Unfortunately, this frequently covers or masks errors. The inaccuracies injure the periodontium. If full coverage must be used, the restoration must fit with the same degree of accuracy as any other type of casting.

RESTORATIVE DENTISTRY AND PERIODONTICS

Restorative dentistry and periodontics complement each other, and their application must be kept in good balance. Periodontists are decrying the damaging effects of many restorations. Restorative dentists should learn and use procedures which will not negate the work of periodontists.

Great strides can be made toward this goal. We should not permit restorative dentistry to become a field of one preparation for all teeth. The MOD onlay, with its "shoeing" of the buccal and lingual cusps and accessory bevels, is a sturdy, time-proved restoration, and there are many advantages in its use (Fig. 6). The same may be said for the pinledge attachment, which should not remain a forgotten restorative procedure. The road to better dentistry is a rough and difficult one, impassable only if we become dogmatic in our ideas and concepts. Let us broaden our horizons by being ever willing to effect changes, to try new techniques, and to even return to some long since discarded ones. Progress is a wonderful word; let us give it its full meaning.

SUMMARY

The relative merits and disadvantages of partial coverage versus the full-cast crown have been discussed. The use of full coverage restorations in a mouth with a high caries index is warranted and valuable. However, its use for every tooth under all conditions as a restorative panacea is wrong and can be damaging. The conservation of tooth structure and the placement of a minimum amount of restorative material in contact with gingival tissues should be foremost in our minds. It is through the use of partial coverage that these objectives may be accomplished. Restorative dentistry and periodontics are so closely related that a separation of one from the other can offer nothing but disastrous results. An increase in skill will eventually carry us on to further progress in dentistry.

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PHYSICAL PROPERTIES AND USE OF RUBBER-BASE IMPRESSION MATERIAL

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RUBBER-BASE IMPRESSION MATERIALS have been applied in many aspects of dentistry. Their use has been advocated in the construction of single or multiple gold inlays, single or multiple gold crowns, pinledge and three-quarter crowns, partial and complete dentures, immediate dentures, pedodontic restorations and space maintainers, and even for stabilization of baseplates for jaw registration.[1-11] It is obvious that rubber-base impression material has been used in practically the entire range of dental restorative procedures. This does not imply that it is a universal impression material or that it is the material of choice in all impression procedures. The irreversible and reversible hydrocolloids, modeling compound, plaster of Paris, waxes, and zinc oxide and eugenol pastes have been used with great success. Rubber-base impression material does have wide applications, and in certain procedures it has proved to be the material of choice for indirect techniques.

Although it possesses several disadvantages, this material does supersede reversible hydrocolloid impression material in the indirect techniques for inlays and for crown and fixed partial denture impressions.[11-15] Rubber-base impression material is easy to handle and requires no heating, storing, or special equipment. It remains dimensionally accurate so that immediate pouring of the cast is unnecessary. Gingival tissue retraction to obtain marginal exposure is not always necessary. The impressions can be easily silver-plated, if desired. The material is strong and will not fracture upon withdrawal. There is no opportunity for pulp injury due to heat.[11] Fixing of the impression is not necessary,[13] and more than one cast can be poured from one impression.[13-16] The surfaces of stone dies are smoother when poured into rubber-base material than when poured into reversible hydrocolloids.[15,16] Some investigators have claimed that it is more accurate than the reversible hydrocolloids, which were previously the standard of accuracy of dental impression materials.[12,14,17] The new silicone-base materials are less effective than the rubber-base materials at present. The silicones have a very short setting time, less dimensional stability, and a poor shelf life. Silicones are superior to the rubber-base materials in that they are easier to handle and more resistant to temperature changes.[18] The superiority of

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the rubber-base material over the compound–copper-band techniques is obvious. The modeling compound, not being an elastic material, will distort upon withdrawal from undercuts.[11] This precludes their use in indirect inlay work. There are many other attributes of the rubber-base material. It will register faulty margins or undercuts.[19] It will reproduce fine detail with great accuracy.[20-22] The hardness of the stone dies in contact with the material will not be affected.[23] There is adequate working time for correct manipulation of the material without subjecting the patient to a prolonged setting time. The material is nonirritating to tissue. The impression can be easily removed from the mouth.[24] Probably its most important advantage concerning fixed prostheses is that a fixed partial denture can be constructed from one impression without resorting to separate impressions of the abutments followed by a full impression utilizing transfers.

The importance of these advantages must not be overemphasized to the extent that good results are to be expected of sloppy technique. The basic requirements for success in the use of this material include retraction or removal of all interfering tissue, use of proper trays, dryness of the field, insertion without entrapment of air, proper mixing, and removal only after complete set.[23] However, by meeting these requirements, excellent results can be expected. Lack of success can be attributed only to poor technique.[25]

PHYSICAL PROPERTIES

The many advantages stated above should be regarded as opinions based on clinical evidence. New techniques for impressions are established by utilizing facts obtained by testing the properties of the material. Many such investigations have been performed employing the rubber-base impression materials.

The material is usually packaged in two tubes. One tube contains the polymer LP-2, titanium dioxide, calcium sulphate, and inorganic fillers. The other tube contains the accelerator lead peroxide, the catalyst sulfur, and the plasticizer, usually olive oil. Several articles discuss the composition and chemistry of the rubber-base materials.[21,26,27]

When the base and the accelerator pastes are spatulated together, a polymerization reaction occurs. The impression is removed from the mouth when this polymerization has progressed to such an extent that the material is strong and resists deformation. For practical usage, this polymerization time is divided into the working time and the setting time. The working time is that from the beginning of spatulation to the time the material loses its plasticity and begins to become very viscous. The impression must be seated within the working time or the strains introduced into the partially polymerized material will be released upon removal and cause distortion. The setting time is that from the beginning of polymerization until the material has obtained sufficient strength and elasticity that it can be withdrawn from the mouth without chance of distortion or fracture. Ideally, the impression material should have a long working time so that the impression procedure can be carried out without undue haste, and it should have a short setting time so that the patient is not subjected to the discomfort of having an impression and tray in the mouth for a long time.

The important factors modifying the working and setting times of these materials are humidity, temperature, accelerator-base proportions, time of spatulation, and accelerators and retarders.[10,28,29] The working time varies from 2 to 4 minutes; the setting time varies from 3 to 7½ minutes.[30] The best accelerator is a drop or two of water incorporated into the mix. Several drops of oleic or stearic acid have been used as retarders.[28,31] With other operating factors standardized, the room humidity seems to play the most important part in causing variations in working times of the material.[7,21] The setting time is adequate for dental procedures; however, a shorter setting time, without decreasing the working time, would always be welcome to both the dentist and patient.[28]

The elasticity of the polymerized rubber-base material is such that impressions can be removed from areas containing large undercuts without distortion. Studies have been made to evaluate the degree of distortion upon removal of the impression, and results have shown that the material will meet American Dental Association specification No. 11 for hydrocolloid materials.[29,30,34] Any great variation in the mixing proportions of the materials, however, will cause inferior elastic properties and is likely to cause distortion of the impression upon removal from the mouth. Most distortion is caused by premature removal of the impression. Although the material may appear to be set after a few minutes in the mouth, the elastic properties are not fully developed until a short time later. Manufacturers have not taken advantage of this information and, in many cases, have given values for time of set that, if followed, will cause distortion of the impression due to premature removal. Leaving the impression in the mouth for several minutes longer than the manufacturer specifies is good procedure. A time of 10 minutes in the mouth is a generalization that will be applicable in most cases.[28,31]

Advocates of the rubber-base material have claimed that one of its chief advantages is the great dimensional stability it exhibits over long periods of time. The material has been claimed to remain stable and accurate for periods varying from several hours to 8 weeks.[10,28,35] Recent work has shown that there is definite shrinkage which continues for some time after removal of the impression from the mouth. This shrinkage can be attributed to several factors. Shrinkage is associated universally with polymerization reactions, and the polymerization reaction of rubber-base materials is no exception. Loss of water can cause some shrinkage, as can the filling up of the small voids in the impression. Studies made to measure this shrinkage have shown values ranging from 0.03 per cent to 0.4 per cent. Shrinkage was less when measured shortly after removal from the mouth; therefore, the shrinkage does continue for some time.[18,31,36,37] The effects of this shrinkage can be minimized by several methods. The use of a stable tray with good adhesive will tend to restrain the material and resist deformation. The use of a 5 to 8 per cent taper on the tooth preparation instead of the classic 2 per cent will also minimize this effect.* A double-mix impression technique also greatly curbs shrinkage.[84] Even though this shrinkage has been inhibited and in most cases is within a range of no clinical significance, it is still advisable to pour impressions as soon as possible.

*Sturdevant, C. M.: Lecture before the Academy of Stomatology, Philadelphia, Nov. 18, 1958.

The accuracy of the rubber-base material has been determined both clinically and by using test models. In both cases, castings were made that fit original and subsequent models with great accuracy.[2,30,38] The material compares favorably with all other impression materials in accuracy and reproduction of fine detail if it is used properly in a clean, dry field.

The surface of the stone dies that are poured in rubber-base impressions is excellent. The hardness of the stone is in no way affected by the material.

Materials with various degrees of consistency and flow have been manufactured. The more viscous materials are used as tray materials where some degree of body is required. The thinner materials are used for syringes where a thick material would not be applicable. The tray materials are quite difficult to mix because of their high viscosity.

Because of their elasticity, it is not surprising to find that the rubber-base impression materials will resist deformation under stress. In fact, they are practically impossible to fracture under compression. Values of 3,000 Gm. per square centimeter have been obtained as the compressive strength. This is greater than that of the reversible hydrocolloid materials.[39,40]

Air bubbles are always present in the mixed material. The best way to reduce them is to spatulate to a thin layer and use a syringe to apply the material to the teeth involved.

Determinations on toxicity have shown that the lead peroxide, a toxic material, does not dissolve in the saliva and cannot harm the patient.[10]

Studies on the shelf life of the material show that it will not deteriorate or change in 5 months.[30] Poor shelf life has always been a problem in the use of the silicone rubbers.

Although much study has been done on the physical properties of the rubber-base impression materials, it remains necessary that an adequate specification be established for them. A.D.A. specification No. 11 for hydrocolloids has been used as a basis for comparison, but it is not applicable in all cases to the rubber-base impression material. Work has been done by at least one investigator to set up specifications for rubber-base materials.[33]

TRAYS

A prerequisite for success in obtaining satisfactory rubber-base material impressions is the selection or construction of a suitable tray. The use of copper bands for this purpose has gradually fallen into disfavor. The lack of sufficient clearance between tooth structure and the band will cause the material to be compressed beyond its elastic limit when the impression is withdrawn from tooth undercuts. The only place where a copper-band and rubber-base material impression is advocated is on abutments prepared to receive full gold or porcelain jacket crowns. However, an impression made in a tray would be as satisfactory and would eliminate the necessity of separate impressions for each abutment tooth. If copper bands are used, they should be sealed on one end with modeling compound or acrylic resin.[20] The bands should fit loosely. They should be made of 30-gauge copper and should be work

hardened so that they will not distort.[15] The inner surface should be roughened or perforations should be made in the band. Even with these precautions, it is best to use a rubber adhesive in them.[30]

If trays are used, it is important that the tray be of proper fit regardless of its composition. Trays that are too large and those with which there is too much space between the tray and the abutment will cause the impression to distort. There should be no more than 6 mm. of space.[29] Use of an excessively large tray complicates the impression technique because too much impression material must be used. It is best not to use stock metal or polystyrene trays unless they fit very well. It is also important, however, to relieve custom-built trays sufficiently to allow enough thickness of material that they can be withdrawn from undercuts without distortion. The rubber-base material should be 2 to 3 mm. thick for optimum results.

Custom-made trays can be fabricated from several materials. A technique utilizing a preliminary plaster impression made over wax relief areas in the mouth is an effective method of constructing a tray. The plaster is painted with rubber adhesive and filled with rubber-base material for the impression.[42-44] Perforated metal mesh can be cut and adapted to the mouth to serve as a tray, also.[20,22]

Trays can be made on models using baseplate material[35] or cold-cure acrylic resin.[28,29,44,45] An excellent method is advocated by Bailey[12] utilizing a study cast. Tissue undercuts and impression areas are relieved in wax. A wax border is placed on the cast to confine the acrylic resin. The adjacent teeth are left open for stops. After a separating medium is applied, the area is covered with an even thickness of cold-cure acrylic resin and a handle is added. After the resin has set, it is removed from the cast, retention holes are drilled, and the tray is coated with rubber adhesive.[12] A method of tray construction that utilizes cold-cure acrylic resin directly in the mouth has been suggested.[23]

One method of tray construction has been the use of an impression compound "snap" impression. A stock tray is filled with heat-softened modeling compound and seated in the mouth. It is removed before it has hardened; all undercut areas are relieved and the areas involved in the impression are relieved to provide several millimeters of thickness of rubber-base material. Adjacent teeth are left untouched to act as stops. The modeling compound is painted with adhesive prior to taking the impression.[2,14,17,18]

Although the distortion of rubber-base material is negligible, the distortion of the modeling compound over a period of time could cause failures. This distortion can be due to elastic memory in the impression compound or to softening of the compound by plasticizers in the rubber-base material. There has been no evidence that any distortion will occur within several hours of the impression procedure. If the impression is not subjected to great temperature changes, longer periods may elapse before recognizable distortion occurs.[10,15,18,20,30,36,47]

If there is any expectation that a prolonged period of time will pass before the impression is poured in stone or electroplated, a well-fitted, custom-made acrylic resin tray should be used. If the impression can be poured within several hours after removal from the mouth, dependable results can be expected from the custom-built

impression compound trays. This method can be carried out at the dental chair, and does not require additional work in the laboratory or an extra visit for the impression. For large span bridges, construction of a custom-built acrylic resin tray for a full-arch impression is recommended.

SYRINGES

Early clinicians found that it was difficult to avoid entrapment of air bubbles in impressions made by a single mix technique. Use of spatulas or plastic instruments to convey some of the material to the tooth was unsatisfactory due to the tackiness and high viscosity of the material. Moreover, a method was needed to ensure that the material would be carried subgingivally. These needs led to the development of two modifications of the rubber-base material. One was a light-bodied or syringe material that could be carried to the tooth and be introduced into all parts of the impression area with ease. The other modification was a heavy-bodied or tray material that would be placed in the impression tray and would be seated over the light-bodied material in the mouth. This heavy-bodied material would act as a restrainer and plunger on the thinner material and ensure its tight and accurate adaptation to the vital impression areas.

Various methods were employed to ensure proper placement of the light-bodied materials. One of the first was the use of "Jiffy" tubes.[1,16,48] These are hollow plastic nozzles that have a small pointed aperture. The syringe material is introduced into these tubes by a plastic instrument, and, by using a piece of cotton or cork as a plunger, the material is injected subgingivally and into the recesses of the impression area. Some investigators modified the anesthetic syringe so it could be used for rubber-base impression material or developed their own syringes,[14,17,23,48] Some manufacturers have made syringes expressly for use with rubber-base materials. These syringes are easily cleaned and are fitted with plastic nozzles that can be cleaned or replaced as needed. There are two methods for loading these syringes. The spatulated material can be placed in a paper funnel and the material pushed to the rear of the syringe. The plunger is then inserted. This method requires meticulous technique in order to ensure that the bulk of the material will be introduced into the syringe and not over the outside of the barrel. If a syringe with a tight plunger is used, another technique may be followed. The tip can be removed and the barrel can be introdued into the spatulated material. The material is drawn into the syringe by pulling back the plunger. The barrel is wiped clean, the tip is replaced, and the syringe is ready for injection. Either of these loading techniques works well when used in conjunction with the syringes manufactured for rubber-base material.

RETRACTION OF TISSUE

The success of the rubber-base material impression depends upon the ability of the material to reproduce subgingival detail. Before a syringe can be introduced subgingivally to inject the rubber-base material, the gingivae must be in a position that will not interfere with the syringe tip and that will allow sufficient thickness of the

material subgingivally. The method of allowing the tray material to set partially before seating the tray, and thus force the thinner syringe material subgingivally, is contraindicated. The partially set material will have strains introduced into it that will manifest themselves in distortion after removal.[29,30]

To solve this problem, various methods of retraction of gingivae have been introduced. The rubber dam has been used, and this method is gentle to gingival tissue, but it is cumbersome. Another mechanical method is the use of cotton-string packs. These strings are forced into the gingival sulcus and left there until the impression is to be made.[21,23] The addition of astringent chemicals to these string packs was a refinement of this method. The use of string which has been dipped in 7 to 8 per cent zinc chloride, left in place for 3 to 5 minutes, has been suggested by some clinicians.[14,49] If this chemical is left in contact with gingival tissue for a prolonged period of time, tissue necrosis will result.

The most common method of gingival retraction used today is that utilizing string packs soaked in 8 per cent racemic epinephrine and dried. A commercial preparation of this epinephrine-soaked string is available.[36] This string is packed into the sulcus and left from 5 to 10 minutes. It is removed prior to insertion of the rubber-base material by a syringe. Local anesthesia of the involved areas is necessary to diminish patient discomfort and reduce hemorrhage and salivation. The epinephrine offers advantages over the zinc chloride in that it reduces hemorrhage and is less irritating to tissue. Local irritation and sloughing of tissue have been ascribed to prolonged application of the packs. Cases of systemic elevation of blood pressure have also been described.[22,23,47] If the packs are removed before 10 minutes, however, local effects will be negligible.[1] Systemic effects, if any, have to be further investigated. In cases where there are severe soft tissue problems such as distal flaps on terminal upper or lower molars, it has been recommended that the excess tissue be removed by dento-electric cautery before an impression procedure is attempted.[23]

IMPRESSION TECHNIQUES

The copper-band and rubber-base material impression technique is basically the same as for a copper-band and compound impression. Methods of preparing the band for the impression have been discussed. It is very important, however, to exert extreme care in the removal of the impression. Since the rubber base is elastic and easily compressed, any permanent deformation of the copper band in removal will cause a deformation of the rubber-base impression. It has been suggested that a wire, bur, or piece of modeling compound be used as a handle to remove the band.[10] A set of pliers that will remove copper-band impressions without distortion is available commercially.

A modification of the copper-band and rubber-base material impression has been adapted in cases where the registration of several teeth is required. Copper-band and rubber-base material impressions of the individual abutments are made and left in place. A stock tray filled with rubber-base material or plaster is seated over the band and allowed to set. The impression is removed, with the copper band imbedded in the tray material.[3,11,16,38] It is often difficult to ensure removal of the

copper bands with the rest of the impression. The copper bands also have a tendency to be displaced upon seating of the tray for the second part of the impression. This procedure cannot be carried out when the abutments are close together.

The procedure of choice is a double-mix technique utilizing a syringe and a custom-built acrylic resin tray or a compound-lined tray. Equal lengths of the base and accelerator pastes of syringe material are spread on a mixing pad. The same is done with the tray material on another pad. Whether the syringe material or tray material is spatulated first is a matter of personal preference. If an assistant is available, of course, both materials can be prepared at once, and while the dentist is injecting the rubber-base material, the assistant can load the tray. This is the preferred method because neither material will have to be put aside after spatulation to wait until spatulation of the other material is completed.

The blade of the spatula is wiped in accelerator paste and this paste is carried to and incorporated with the polymer paste. They are thoroughly spatulated, making sure that the material is spread out thinly to eliminate entrapped air. When the color is homogeneous, it may be assumed that the material is completely spatulated. The time elapsed should be no more than 1 minute. The syringe material is less viscous and less time is required for its thorough spatulation.

The tray material is placed in the tray, covering all surfaces and taking care to entrap no air. The syringe material is loaded into the syringe either by the paper funnel or by suction. When the syringe is ready, the cotton packs are removed from the gingival sulci and, after ensuring complete dryness and débridement of the area, the syringe material is injected. The tip of the syringe is placed deep in the gingival sulcus and, keeping the tip under the surface of the escaping material, the cervical areas of the tooth are covered. The syringe is then worked occlusally making sure that the syringe tip is in contact with the tooth. All inaccessible areas and line angles are injected until the entire impression area is covered. Then the loaded tray is seated with light pressure and the tray is held in place in the mouth for at least 10 minutes. If desired, the "set" can be estimated by injecting some syringe material between two uninvolved teeth. When this material can be compressed with an explorer without resultant deformation, the material has acquired enough elastic properties for removal.

COMMON MISCONCEPTIONS

There are several common misconceptions regarding use of this material. The impression does not require a snap removal. The elastic properties are such that no deformation results when a firm, even withdrawal of the impression is made.[15,30] Repairing of faulty impressions by reusing them with a thin wash of new material is not recommended. Distortion due to excess compression is inevitable.[30] It is always best to remove all the material and repeat the entire impression procedure. A moist surface on the abutments is not required. The rubber-base material will separate cleanly from dry tooth structure.[14,15] In fact, moisture will result in an inferior impression due to the presence of cracks and voids.

The National Bureau of Standards recommends that at least ½ hour elapse before the impression is poured. This time period is required to allow the optimum elastic properties to develop.[21]

One rubber-base material, Neoplex, passes through a nonsticky stage from 2½ to 3 minutes after spatulation. Small pieces of this can be picked up with moistened fingers and forced into the impression areas with the fingers or a plastic instrument before the tray containing the bulk of the material is seated. This technique eliminates the need for a syringe.[22]

ELECTROPLATING, DIES, AND CASTS

Although electroplating of the impression may be desired from the standpoints of better marginal definition, strength of the cast, and ease of waxing and finishing, there has been some difficulty in obtaining accurate casts when plating is attempted. This has been most evident with attempts at copperplating. The copper does not deposit a smooth surface on the rubber-base material. Distortion was obtained in several cases.[11,29,30]

Silver is the metal of choice for electroplating these impressions. A fine, smooth layer of silver can be deposited by utilizing a silver cyanide solution and silver anode. A current is run for several hours through the solution containing the impression. It is necessary to paint the surface of the impression with a colloidal silver solution before immersion.[50] The main disadvantage of plating is that usually the impression must be left standing for a day or more or it must be transported to another place for plating. This increases chances for error.

Unplated stone casts have given excellent results and are very accurate, but they must be handled with care to avoid breakage. A fine quality hard die stone should be used to pour the casts. Because of the excellent elastic properties and strength of the rubber-base material, several dies or casts can be poured in one impression. Some clinicians suggest that the abutment areas of the impression be filled with stone and a dowel pin inserted. After the stone is set, the separate dies are removed and the entire impression is filled with stone. The gingival margins can be finished on the dies; the occlusion, contact, and contour are finished on the articulated cast.[22]

Other dentists have developed one-cast techniques that utilize a master cast which is sectioned or which contains removable dies keyed into position.[1,11,14,17,20,23,43] Sturdevant has suggested an excellent method in which thin stainless steel strips are used to separate the dies.[15,36] This method combined with a technique that utilizes die pins locked into position with a key rod will provide a cast with removable dies that will accurately reproduce the entire area.

CONCLUSION

Results are now being obtained with rubber-base impression materials in indirect techniques that justify the acceptance of this material in clinical practice and teaching institutions. By following simple techniques and exerting moderate care, these successful results can be obtained with great consistency.

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165 Chancellor Ave.
Newark, N. J.

AMERICAN DENTURE SOCIETY ESSAY CONTEST WINNERS

GERALD W. GASTON, D.D.S.

RUDOLPH M. FEUERSTEIN, D.D.S.

The American Denture Society announces the winners of its Seventh Essay Contest for senior dental students. Their essays are published in this issue of the the JOURNAL OF PROSTHETIC DENTISTRY.

The first prize of $500 was awarded to Gerald W. Gaston of Elyria, Ohio. He was a student at the Ohio State University, College of Dentistry, and was graduated in June, 1959. He is now with the United States Public Health Service as an Assistant Dental Surgeon (Intern) at the United States Public Health Service Hospital in Baltimore, Maryland.

The second prize of $300 was awarded to Rudolph M. Feuerstein of Newark, New Jersey. He attended the School of Dentistry, Temple University, and was graduated in June, 1959. He is now a First Lieutenant in the Dental Corps of the United States Army, serving with the Dental Detachment, U.S.A.G., Fort Bragg, North Carolina.

BOOK REVIEWS

PEDIATRIC DENTISTRY. By Michael Cohen, D.M.D., et al., St. Louis, 1957, The C. V. Mosby Company. Pp. 589, 395 illustrations, including 9 in color, indexed. Price $14.75.

The material is this textbook is presented by Dr. Cohen and 17 contributing authors. It covers the various phases of dentistry encountered in the practice of dentistry for children.

The book may very well serve as a text for undergraduate and graduate teaching, and as a splendid reference book for the general practitioner of dentistry.

There are 17 chapters, some of which have coauthors; this tends to give a diverse and broad coverage of the material.

The book begins with the embryologic development of the head, face and oral cavity. Following this is a discussion of the physical growth as well as the psychologic development of the child. With this as background, the authors devote considerable space to the evolution and care of the primary and transitional dentitions.

The recognition and treatment of the diseases of the teeth and supporting structures and the soft tissues of the oral cavity are well presented.

The chapter, "Psychological Development of the Child," it seems to the reviewer, is too involved and fails to delineate practical procedures for patient management in the dental office.

The chapter, "The Handicapped Child," is a very definite asset to the book because of the relatively recent recognition of the desperate need for dental service among this group of patients.

The book closes with a chapter on the public health aspects of dentistry for children, which is most timely since the dentist in his community is more and more sought after to plan and initiate a dental program.

Pediatric Dentistry has a great deal to offer those who are interested in the practice of dentistry for children.

L. S. Pettit, D.D.S.

A TEXT-BOOK OF ORTHODONTIA. By Robert H. W. Strang, M.D., D.D.S., and Will M. Thompson, B.S., D.D.S., ed. 4, Philadelphia, 1958, Lea & Febiger. Pp. 880, 1178 illustrations on 647 figures and 5 plates, some in color, indexed. Price $20.00.

For the first time this book has a coauthor, which means that it will continue to be published for years to come. The senior author welcomed the junior author first as a student, subsequently as an associate instructor in courses given by the senior author, and later as his aid in prior editions. The authors have as their main object the foundation, both in theory and in technique, of the edgewise arch appliance. Since the book was limited to one appliance, it was possible to describe every technical procedure in a detailed, step-by-step procedure.

The junior author was given the task of preparing the chapter dealing with cephalometrics, an entirely new and valuable addition to this volume. This material was interwoven into the text of the book and, whenever possible, correlated within the well-arranged chapters on treatment of malocclusion.

The material covered is quite detailed at times from a technical standpoint. Descriptive writing alone does not suffice in these instances, and the profuse use of figures, diagrams, and photographs helps to clarify these areas; the excellent quality of the paper enhances the illustrations.

Unlike other textbooks, this one is unique in that it attempts to describe completely only one type of appliance. The reviewer feels that it accomplishes its purpose and reaches those who want a basic background in the edgewise arch orthodontic appliance.

Benjamin H. Williams, D.D.S.

DESIGN FOR MAJOR CLEFT PALATE. By Horace Hayman Boyle, F.D.S., H.D.D., (R.C.S.EDIN.), H.D.D., L.D.S. (R.F.P.S.GLAS.), London, 1957, Staples Press Limited. Pp. 120, 65 illustrations, indexed. Price $6.00.

"This book has been prepared primarily for the dentist who is interested in the unusual prosthodontic problem. It has been designed also for the information of the dental technician, in order that the two can follow out procedures in their sequence." These statements taken from the author's preface state the purpose of this short book.

Of the 120 pages, only 40 are actually spent on a description of the technique of constructing an appliance for a cleft palate. The rest of the book is made up of a great many photographs illustrating the high points in the construction of protheses for 5 patients.

The subject matter is well organized. The book is concise and this is one of its shortcomings, because it does not give detailed instructions on how to do some steps which are in themselves very complex.

The text is hard to follow at times because certain theories, important to the author's technique, are mentioned but never fully explained.

The quality of the binding and of the photographs is very poor.

The author attempts to show how to construct a complete denture with an obturator for a cleft palate. He describes an impression method, the setting of the teeth, and the construction of the obturator. His views on the subject of saving teeth are not in accordance with those generally held in this country and may evoke some comment among the readers.

Though Dr. Boyle had a laudable purpose in writing this book, I do not believe that his mission was accomplished. There are some interesting facts, but not enough detailed information to help a dentist construct a denture for a patient with a cleft palate.

James B. Boucher, D.D.S.

PHARMACOLOGY AND ORAL THERAPEUTICS. By Edward C. Dobbs, B.S., D.D.S., F.A.C.D., St. Louis, 1956, The C. V. Mosby Company. Pp. 579, indexed, illustrated. Price $9.00.

This is the eleventh revised edition of a book first published in 1909. It is designed primarily as a teaching aid for dental students and hygienists studying pharmacology, and for practicing dentists as a reference book on newer drugs and preparations. The contents are divided into two sections. The first section is restricted to pharmacology; the second is allocated to the study of dental and oral therapeutics—a unique feature.

The author has classified drugs according to their therapeutic effect, e.g., drugs which depress the central nervous system, drugs which stimulate the central nervous system, general anesthetics, local ansethetics, drugs which affect the heart and blood, and those which affect the respiratory, gastrointestinal, and genitourinary systems, etc.

Each drug is listed usually by trade name, generic and chemical composition, its pharmacodynamics, common usage, possible side effects, dosage, and toxicity. These monographs are concise and relevant, and show that the author has been guided by his extensive classroom experience and clinical practice.

The bibliographies are placed in fine print at the bottom of the page on which the citation appears—a welcome innovation. Another desirable feature is the inclusion of pharmaceutical classes, methods, and definitions, methods of administration, and factors which affect the action of drugs.

The binding, paper, size of type, printing, spacing, and format are excellent, for which the publishers are to be commended.

It is gratifying that a book of this size can incorporate most of the essentials from this comprehensive subject matter succinctly and clearly.

I would recommend this volume to anyone interested in pharmacology.

W. Russell Kampfer, D.D.S., LL.B.

THE DESIGN AND CONSTRUCTION OF REMOVABLE ORTHODONTIC APPLIANCES. By C. Philip Adams, B.D.S., F.D.S., D. Orth., ed. 2, Bristol, Great Britain, 1957, John Wright & Sons Ltd., The Williams & Wilkins Co., Baltimore, exclusive U. S. agents. Pp. 120, 173 illustrations, indexed. Price $5.50.

The first edition of this book was written in an attempt to establish a systematic approach to the construction of removable orthodontic appliances. Some of the material included had been originally published in the *Dental Practitioner,* and to it was added other material from the *Dental Record.* With all of this have been included factors which affect the design and construction of removable orthodontic appliances.

This second edition has elaborated upon the use of expansion screws, and added sections dealing with expansion and welding. The author has attempted to present the practical application in all areas of his subject matter.

His style of writing is a little hard to follow at times, but the organization of the subject matter is well oriented with many illustration to show both technique and clinical results. The book is well bound and printed on a high-gloss paper.

This book in one's library could be extremely useful. The chapter on expansion appliances is quite applicable to the prosthodontist handling cleft palate cases. There are several examples of simple tooth movements to facilitate a better position for abutment teeth in fixed or removable prostheses.

One point was stressed in the first chapter and then followed up in a chapter of its own with explanations. Bodily movement of teeth is quite difficult and, "As a general rule, removable appliances tilt the teeth, producing movement of the crowns." The author, in Chapter X, attempts to give techniques to produce bodily movement and shows several illustrations of clinical cases. It might have been more positive to show before and after x-rays of such areas, also, to prove his point.

Benjamin H. Williams, D.D.S.

INTERVIEWING, COUNSELLING, AND MANAGING DENTAL PATIENTS. By S. Joseph Bregstein, D.D.S., Englewood Cliffs, New York, 1957, Prentice-Hall, Inc. Pp. 311, indexed. Price $7.50.

This volume represents an ambitious attempt by a well-known author and lecturer in the field of practice administration to give "expert guidance for creating an effective and profitable dentist-patient relationship." The author confidently states that those who carefully study and follow each suggested step will "enjoy the success so many others have achieved."

The material presented is divided into 29 chapters arranged in 11 sections: "The Development of Patient Rapport," "The First Interview," "The Second Interview," "Completing Your Case Presentation," "The Patient and Fees," "Your Patients and How to Retain Them," "Dealing with Juvenile Patients," "Letters That Improve Dentist-Patient Relationships," "Dental Psychiatry—How to Apply it Successfully," "How to Use Salesmanship on Patients," and "Hypnosis in Dentistry."

The book contains no charts or illustrations, yet it does not suffer the slightest loss in reader interest because of this fact. This lack is more than counterbalanced by a very readable type, numerous subheadings, and a very ingenious "Points to Remember" summary at the end of each chapter, all of which makes for a book that is very easy to read and follow.

Because of the great need for reliable, ethical information on this phase of practice, a book of this type is always enthusiastically received. However, the reader will not proceed far before receiving somewhat of a shock. As early as page 7 the author suggests, as one method of showing professional skill, that upon completing the cementation of an inlay the assistant be called, the patient handed a mirror, and the dentist then say, "Miss Smith, I want you to see another of our perfect inlays. Look how it fits at the gum line."

Because of this and other similar examples of what must be considered rather bad taste, to say the least, many will seriously question the appropriateness of the author's approach. Others may go so far as to class the book as unacceptable.

After this rather unfortunate beginning the author then proceeds to suggest a great many solutions for some of our most vexing problems. Most of the suggestions, while quite naturally flavored by the writer's experience as a practitioner in a large Eastern city, have considerable merit in principle.

Also sprinkled throughout the book can be found many fine examples of the usefulness of basic psychologic principles of human behavior. Yet, because they are not pinpointed or explained as such, most of these illustrations will pass unnoticed and unappreciated except by the keenest students of applied psychology. It is very evident that the author chose to emphasize "how" rather than "why."

For that reason, after carefully analyzing the text, this reviewer had the feeling that the book skirts the perimeter yet never quite comes to grips with the real problem, namely, the great need for a better understanding of the reasons underlying motivation. The author, however, may be right. Perhaps there are not enough dentists who actually desire such a book.

To avoid being unduly critical, it should be stated unquestionably that the author's goal and motives are above reproach. While the book may lack somewhat in finesse, Dr. Bregstein is to be congratulated for his sincere effort to contribute to a literature that is woefully inadequate.

Cecil H. Bliss, D.D.S.

THE PHYSIOLOGICAL FOUNDATION OF DENTAL PRACTICE. By L. L. Langley, A.B., M.A., Ph.D., LL.B., and E. Cheraskin, A.B., M.A., M.D., D.M.D. St. Louis, 1956, The C. V. Mosby Co. Pp. 587, illustrated, indexed. Price $9.75.

This book is unique in that it is the only general physiology textbook written especially for the dental profession. Whereas the dental student and practicing dentist have had to use books correlated primarily with medical problems, this book presents physiology as it applies to dental situations. However, the basic concepts of general physiology are not neglected.

The subject matter is presented in a different and interesting form. The book is divided into five main topics which are subdivided into fifty chapters. The main topic divisions are (1) the nervous system, (2) circulation, (3) respiration, (4) excretion, and (5) alimentation. Each chapter is preceded by a brief introduction to correlate earlier material and concludes with a summary which lists precisely the important points of that chapter. Both of these parts are extremely helpful to the individual who is not primarily a physiologist, but who is learning or reviewing the subject. The text is supplemented with 192 illustrations which pertain to dentistry.

Although some physiologists do not consider this book to be complete in certain topics, it achieves the purposes for which it was written. I found the book interesting and certainly adequate in physiologic content from a dental standpoint. Its use as a textbook for dental students is recommended.

Judson C. Hickey, D.D.S., M.Sc.

NEWS AND NOTES

MEETINGS

American Equilibration Society, Sheraton-Blackstone Hotel, Chicago, Ill., Feb. 4, 1960.

American Denture Society, Congress Hotel, Chicago, Ill., Feb. 5 and 6, 1960.

American Academy of Restorative Dentistry, Conrad Hilton Hotel, Chicago, Ill., Feb. 6 and 7, 1960.

American Academy of Crown and Bridge Prosthodontics, Conrad Hilton Hotel, Chicago, Ill., Feb. 6 and 7, 1960.

Southeastern Academy of Prosthodontics, Monteleone Hotel, New Orleans, La., April 29 to May 1, 1960.

American Association for Cleft Palate Rehabilitation, Brown Palace Hotel, Denver, Colo., May 12 to 14, 1960. For further information, write to Dr. D. C. Spriestersbach, Department of Otolaryngology, University Hospitals, Iowa City, Iowa.

Academy of Denture Prosthetics, La Concha Hotel, San Juan, Puerto Rico, June 19 to 24, 1960.

American Dental Society of Europe, Edinburgh, Scotland, July 5 to 8, 1960.

Indonesian Dental Association, Bandung, Indonesia, during July, 1960. For further information write to Dr. R. M. Soelarko, Congress Secretary, Indonesian Dental Association, 55 Riaustreet, Bandung, Indonesia.

Canadian Dental Association, Ottawa, Canada, Sept. 25 to 28, 1960.

American Society of Oral Surgeons, Westward Ho Hotel, Phoenix, Ariz., Oct. 12 to 15, 1960. For further information write to Mr. D. C. Trexler, Executive Secretary, 840 North Lake Shore Drive, Chicago 11, Ill.

ANNOUNCEMENTS

The Chicago Academy of Dental Research will sponsor their annual seminar on Feb. 6 and 7, 1960 (before the Midwinter meeting), at the Conrad Hilton Hotel. The subjects will be "Occlusal Concepts" and "Periodontal Prosthesis."

For further information, write to Dr. W. G. Gordon, Director of Seminars, Chicago Academy of Dental Research, 111 North Wabash, Chicago 2, Ill.

An Oren A. Oliver Appreciation Banquet is being planned by the Tennessee State Dental Association for Sunday evening, May 1, 1960, at 6:30 P.M., Hotel Peabody, Memphis, Tenn.

For further information, write to Dr. Lloyd C. Templeton, President, Tennessee State Dental Association, 1112 Exchange Bldg., Memphis 3, Tenn.

Dentists from the states of Washington, Oregon, California, Montana, Nevada, Idaho, Utah, Arizona, Alaska, Hawaii, and the Canadian Provinces of Alberta and British Columbia are invited to attend the Eleventh Triennial Pacific Coast Dental Conference in Portland, Ore., July 10 to 14, 1960. Dentists in other parts of the country planning to be in the North-

west during this period and wishing to attend this conference may obtain further information and application for registration from Dr. Kenneth R. Jensen, 1033 Southwest Yamhill St., Portland 5, Ore.

Reprints of the "Glossary of Prosthodontic Terms" may be obtained by writing to Glossary Reprints, 3939 Old Brownsboro Road, Louisville 7, Ky. The price is fifty cents per copy, with a 20 per cent discount allowed on purchases of 20 or more copies. Cash, check, or purchase order *must* accompany the order.

Reprints of "Principles, Concepts, and Practices in Prosthodontics" may be obtained by writing Dr. W. Les Warburton, Secretary-Treasurer, Academy of Denture Prosthetics, 807 Medical Arts Bldg., Salt Lake City 11, Utah. The price is twenty-five cents per copy, with a 20 per cent discount allowed on purchases of 20 or more copies. Cash, check, or purchase order *must* accompany the order.

The American Equilibration Society has issued a leaflet entitled "Treatment for Returning the Lower Jaw to a Condition of Equilibrium." This leaflet explains to the patient, in simple terms, how stress in the temporomandibular joint can cause such troubles as headache, facial pains, dizziness, deafness, nervousness, and others, and how the stress can be removed by means of changing the occlusion of the teeth.

Any dentist or physician may obtain a copy of the leaflet by writing to the Secretary of the Society, Dr. Raymond C. Van Dam, 11431 South Halsted St., Chicago 28, Ill.

"Artificial Dentures—A Health Service or a Health Hazard" is the title of a new leaflet published by the American Dental Association, Bureau of Dental Health Education. The leaflet explains to the public that artificial dentures can be a health service, if they have the advantage of professional attention from a dentist, or a health hazard, if they attempt to get denture services from nonprofessional sources. The leaflet discusses the education of a dentist and, in some detail, the many factors he takes into consideration in preparing dentures for a patient. It points out that those persons other than dentists who make dentures directly for the public are unqualified and probably are operating in violation of state laws regulating the practice of dentistry.

The leaflet is available from the Order Department, American Dental Association, 222 East Superior St., Chicago, Ill., at the following prices: 25 for $.75; 50 for $1.40; 100 for $2.25; 500 for $10.00. The Order Department will give price quotations for larger quantities on request.

Boston University, School of Medicine, Division of Graduate Studies, Department of Stomatology, announces the following postgraduate courses:

Techniques in the General Practice of Dentistry, Dr. Henry M. Goldman, Dr. David J. Baraban, Dr. Leo Talkov, Dr. Herbert Schilder, Dr. Gerald Kramer, Dr. Chester Landy, and Dr. Harold Berk, March 7 to 12, 1960.

Advanced Course in Periodontology, Dr. Henry M. Goldman, Dr. Bernard S. Chaikin, Dr. Gerald M. Kramer, Dr. William Pendergast, and Dr. Jack Bloom, March 14 to 19, 1960.

Complete Denture Prosthesis, Dr. Chester Landy, March 28 to April 1, 1960.

Periodontal Therapy, Dr. Henry M. Goldman, Dr. Bernard S. Chaikin, Dr. Gerald M. Kramer, Dr. William Pendergast, Dr. Jack Bloom, and Associates, April 4 to 9, 1960.

Apicoectomy-Surgical Endodontic Procedures, Dr. Herbert Schilder and Dr. Leonard Parris, April 18 to 22, 1960.

Periodontal Pathology, Dr. Henry M. Goldman and Dr. Jack Bloom, April 25 to 30, 1960.

Pulp Protection in Operative Dentistry, Dr. Harold Berk, May 12 to 14, 1960.

Periodontal Prosthesis, Dr. Leo Talkov, Dr. David J. Baraban, Dr. Henry M. Goldman, Dr. Bernard S. Chaikin, and Dr. Gerald M. Kramer, May 16 to 20, 1960.

Surgical Procedures in Periodontal Therapy, Dr. Lewis Fox and Associates, May 23 to 27, 1960.

For further information, write to Director of Postgraduate Studies, Department of Stomatology, Massachusetts Memorial Hospitals, 750 Harrison Ave., Boston 18, Mass.

Indiana University, School of Dentistry announces the following postgraduate courses:

Dental Assistants, Feb. 24 and 25, 1960.

Crown and Bridge, April 11 to 14, 1960.

Complete Denture Construction, June 15, 22, 29, and July 6 and 13, 1960.

Partial Denture Design and Construction, July 11 to 14 and on four consecutive Thursdays, June 23 and 30 and July 7 and 14, 1960.

Course for Laboratory Technicians on Partial Denture Design and Construction, July 25 to 28, 1960.

For further information and application, write to Indiana University, School of Dentistry, 1121 W. Michigan St., Indianapolis 2, Ind.

The Loyola University, School of Dentistry, announces the following postgraduate courses:

Complete Dentures, Feb. 11 to 13, 1960.

Anatomy of the Head and Neck, Feb. 15 to 17, 1960.

Principles of Occlusion and Articulation (part I), March 1 and 2, 1960.

Surgical Anatomy, March 7 to 11, 1960.

Principles of Occlusion and Articulation (part II), March 22 and 23, 1960.

Diagnosis, April 4 to 6, 1960.

Principles of Occlusion and Articulation (part III), April 12 and 13, 1960.

Differential Diagnosis of Oral Lesions, April 20 to 22, 1960.

For further information and application, write to Director, Postgraduate Division, Loyola University, School of Dentistry, 1757 W. Harrison St., Chicago 12, Ill.

Northwestern University Dental School announces the following postgraduate courses:

Current Concepts in Operative Dentistry Applied to Daily Practice, Feb. 1 to 3, 1960.

Basic Oral Surgery, Feb. 1 to 5, 1960.

Newer Concepts in Periodontics, Feb. 1 to 5, 1960.

Pedodontics, Feb. 11 and 12, 1960.

Analysis and Treatment of the Stomatognathic System—for the Orthodontist, Feb. 22 to 24, 1960.

Major Oral Surgery—A, Feb. 29 through March 11, 1960.

Analysis and Treatment of the Stomatognathic System—for the General Practitioner, March 14 and 15, 1960.

Intermediate Oral Surgery, March 14 to 18, 1960.

Complete Denture Procedures, March 28 to 31, 1960.

Endodontics, March 28 to 30, 1960.

Major Oral Surgery—B, April 4 to 8, 1960.

Maxillofacial Prosthesis, April 4 to 6, 1960.

A Practical Approach to the Use of Gold Foil, April 4 and 5, 1960.

Procedures in Dental Prosthetics as Related to Physiologic Function, April 20 to 22, 1960.

Diagnosis, Roentgenography and Treatment Planning, April 27 and 28, 1960.

Edmund Noyes Memorial Lecture, May 4, 1960.

The Use of Drugs in Dental Practice, May 9 to 11, 1960.

Prosthetic and Orthodontic Rehabilitation for the Cleft Palate Patient, May 9 and 10, 1960.

Conference for Teachers of Pedodontics, June 6 and 7, 1960.

For further information and application, write to Northwestern University Dental School, 311 East Chicago Ave., Chicago 11, Ill.

The Ohio State University, College of Dentistry, announces the following postgraduate courses:

Pedodontics, Feb. 15 to 19, 1960.

Endodontics, March 1 to 4, 1960.

General Anesthesia, April 4 to 8, 1960.

Oral Surgery, April 11 to 15, 1960.

Clinical Periodontics, April 11 to 15, 1960.

Post-College Assembly, April 20 and 21, 1960.

Partial Denture Prosthodontics, May 2 to 6, 1960.

Complete Denture Prosthodontics, May 9 to 13, 1960.

Dental Drugs in Action, May 19 and 20, 1960.

For further information and application, write to Postgraduate Division, College of Dentistry, The Ohio State University, 305 West 12th Ave., Columbus 10, Ohio.

The University of Pennsylvania, School of Dentistry, announces the following postgraduate courses:

Periodontal Prosthesis, Feb. 8 to 12, 1960.

Partial Dentures, Feb. 29 to March 4, 1960.

Practice Administration, March 7 and 8, 1960.

Practical and Simplified Procedures in Crown and Bridge Prosthesis, March 14 to 18, 1960.

For further information and application, write to Director of Postgraduate Courses, University of Pennsylvania, School of Dentistry, 4001 Spruce St., Philadelphia 4, Pa.

The University of Pittsburgh, School of Dentistry, Division of Graduate Education, is accepting applications for graduate study in the fields of Anesthesiology, Oral Surgery, Orthodontics, and Prosthodontics, leading to the Master of Science degree. Selection of students for the fall session of 1960 will be made in April, 1960.

A nondegree, full-time 12-month course in General Anesthesia is also available for qualified dental graduates.

For further information and application forms, write to Director of Graduate Education, University of Pittsburgh, School of Dentistry, Pittsburgh 13, Pa.

Temple University School of Dentistry announces the following postgraduate courses:

Anatomy—Head and Neck Dissection, Wednesdays, Feb. 3 to June 8, 1960.

Periodontal Prosthesis, Feb. 8 to 12, 1960.

Advanced Fixed Prosthesis, Feb. 8 to 13, 1960.

Present-Day Periodontal Practice, 1 day a week for 10 weeks, Feb. 16 through April 26, 1960.

Practice Administration, Feb. 27, 1960.

Clinical Diangosis and Oral Medicine, Feb. 29 to March 4, 1960.

Electronic Electrosurgery, March 18 and 19, 1960.

Complete Denture Prosthesis, March 21 to 26, 1960.

Advanced Surgical Techniques in Periodontal Therapy, April 4 to 9, 1960.

Graduate Orthodontics, Sept. 12, 1960, a 2-year course.

For further information and application, write to Dr. Louis Herman, Director of Postgraduate Studies, Temple University School of Dentistry, 3223 North Broad St., Philadelphia 40, Pa.

Tufts University School of Dental Medicine announces the following postgraduate courses:

Pin Ledge Technique, Feb. 4 and 5, 1960.

Oral Pathology for the Oral Surgeon, each Thursday afternoon, Feb. 4 to March 31, 1960.

Orthodontic Principles of Interest to the General Practitioner, each Wednesday, Feb. 10 to March 30, 1960.

How to Improve Efficiency and Minimize Fatigue in Dental Practice, Feb. 11 and 12, 1960.

Oral Rehabilitation, Feb. 25 to 27, 1960.

A Demonstration Course in Complete Upper and Lower Dentures, Feb. 11 to 13, 1960.

Minor Oral Surgery, each Wednesday, March 2 to April 6, 1960.

Clinical Adjustment of the Occlusion, March 14 to 16, 1960.

Hypnosis and Its Clinical Applications, March 17 to 23, 1960.

Tooth and Denture Base Esthetics, March 21 to 23, 1960.

Full Denture Implants, March 28 to April 1, 1960.

Advanced Surgical Periodontal Treatment Techniques, April 4 to 6, 1960.

A Special Participation Course in Periodontology, April 25 to 29, 1960.

Special Postgraduate Refresher Course in Prosthetics for the Periodontal Patient, May 9 to 12, 1960.

A Special Postgraduate Refresher Course in the Diagnosis and Treatment of Pain and Other Symptoms Arising from Temporomandibular Joint Disturbances, May 24 and 25, 1960.

Complete Denture Prosthesis, June 6 to 10, 1960.

Applications are now being accepted for two Research Fellowships in Oral Pathology and Periodontology for the school year beginning September, 1960.

For further information and application, write to Director of Graduate and Postgraduate Studies, Tufts University School of Dental Medicine, 136 Harrison Ave., Boston, Mass.

The Medical College of Virginia, School of Dentistry, announces the following postgraduate course:

Anatomy of the Head and Neck, March 14 to 18, 1960.

For further information and application, write to Dr. H. T. Knighton, Director of Postgraduate Instruction, Medical College of Virginia, School of Dentistry, Richmond, Va.

The Ohio State University, College of Dentistry, announces that it is receiving applications of students for the Curriculum of Dental Laboratory Technology. This course of study of the laboratory phases of prosthodontics extends over two academic years and leads to a Certificate of Graduate Dental Laboratory Technologist.

Application forms may be obtained by writing to the Entrance Board, The Ohio State University, Administration Bldg., 190 N. Oval Dr., Columbus 10, Ohio. Applications should be received by the Entrance Board by Aug. 1, 1960, for admission to the class starting Sept. 26, 1960.

For further information, write to the Chairman of Dental Laboratory Technology, The Ohio State University, College of Dentistry, 305 West 12th Ave., Columbus 10, Ohio.

DIRECTORY

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Next Meeting: La Concha Hotel, San Juan, Puerto Rico, June 19 to 24, 1960.

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Next Meeting: Congress Hotel, Chicago, Ill., Feb. 5 and 6, 1960.

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